MTM

Journal of Methods-Time Measurement

In This Issue . . .

MTM Standards for Multi-Plant Operation

Training Operators to Follow MTM Methods

Auditing Methods

Developing an Improved Plant Layout with MTM

Establishing Methods and Standards with MTM

MTM Standards Used in Heavy Industry

Use of Motion Combinations for Developing Standard Data

VOL. V NO. 5 Jan.-Dec. 1959 MTM ASSOCIATION

MTM

The Journal of Methods-Time Measurement

January-February 1959

MTM ASSOCIATION FOR STANDARDS AND RESEARCH

MTM

The Journal of Methods-Time Measurement

January-February 1959

MTM Association

Editor. . . . . .Richard F. Stoll

The Journal is published five times annually during the months of February, April, June, August, and December.

Subscriptions Available Through
MTM Association, 216 S. State Street
Ann Arbor, Michigan

Subscription: $2.50 per year in U.S. and Possessions and Canada. Single copy, 60 cents. Elsewhere $3.50 per year. Single copy, 75 cents.

Volume rate for 25 or more copies of any one issue - $ .50 per copy.

Controlled circulation permit
Ann Arbor, Michigan

CONTENTS

Feature

I - International MTM Conference . . . 1

Applications—Presented at A. T. Kearney Seminar, October, 1958

I - MTM Standards for Multi-Plant Operation 5
E. W. Sloan

II - Training Operators to Follow MTM Methods 13
Miss Ginny Wonder

III - Auditing Methods 18
Evan DeJong

IV - Developing an Improved Plant Layout with MTM 29
Wayne Howart

V - Establishing Methods and Standards with MTM 32
Lloyd M. Griffin

VI - MTM Standards Used in Heavy Industry 38
Paul Broadstone

VII - Use of Motion Combinations for Developing Standard Data 44
William E. Ross

Announcements 49

1959 Association Officers

Delmar W. Karger
President

HONORARY MEMBERS
Dr. Lillian M. Gilbreth
Dr. H. B. Maynard

PRESIDENT
Delmar W. Karger

VICE PRESIDENTS
Serge A. Birn
Malcolm Gotterer
Richard Keenan
William McIntire
C. H. Van Horne

SECRETARY
A. H. Walter

TREASURER
Robert Isaacson

EXECUTIVE SECRETARY
Richard F. Stoll

GENERAL DIRECTORS
Douglas W. Beale
Stanley Block
J. W. Curry
T. Blair Evans
James A. Gage
Jerome Goldman
John W. Hannon
James Kershner
Richard Knoble
Robert Mitchell
Gordon Quimby
Robert C. Rick
Virgil Rotroff
Harry Schwan
T. R. Snakenberg
Donald Wheeler
Thomas R. Williams

Benjamin Borchardt
EX-OFFICIO

APPOINTIVE OFFICES
ASSISTANT TO PRESIDENT
C. H. Van Horne

COMMITTEE CHAIRMEN

W. D. Bryson
Donald Farr
Fred Fisher
Jerome Goldman
James Kershner
Richard Knoble
William McIntire
Dr. H. B. Maynard
Robert Moore
A. H. Walter
John A. Willard
C. H. Van Horne

2nd INTERNATIONAL M. T. M. -CONFERENCE, SCHEVENINGEN/KURHAUS APRIL, 1959

Sponsored by Nederlands M. T. M. Genootschap

Secretariat: Nederlands Instituut voor Efficiency
Prins Hendrikplein 17 The Hague

Just as at the first Conference, the purpose now is again to attain an exchange of experiences between M. T. M. -users and -experts. This second International Conference has to be considered of great importance for

- the establishment and maintenance of contacts between M. T. M. -users and -experts in the various countries;
- the strengthening of the ties between the various national M. T. M. -Associations in the Western Hemisphere.

This Conference is intended to further contacts and to exchange experiences between M. T. M. -users and -experts who deal with equivalent problems in the same or similar branches of business in the various countries. The scheme of the programme comprises:

1st day: introduction and getting acquainted;
2nd day: treatment of specific subjects in sections together with visits to enterprises;
3rd day: case histories and proceedings of the sectional meetings;
4th day: consolidation of the contacts made.

Moreover, room has been left for joint recreation, notably excursions have been planned to the blossoming bulb-fields (Keukenhof) in the afternoon of April 27th and to the storm-sluice/Delta-plan for the whole day on April 30th.
For further particulars we refer to the enclosed detailed provisional programme from which you will see, among other things, that in any case on April 29th a simultaneous translation-system and interpreters will be present.

FEATURE

PROVISIONAL PROGRAMME

Monday, 27th April, 1959

9.00 h.	Registration at the Kurhaus and supply of tickets, documents, a.s.o.
9.00 h.	Reception of guests by the Board of the Nederlands M.T.M.-Genootschap
9.30 h.	Opening of the Conference by the President of the Nederlands M.T.M.-Genootschap, mr ir R. F. Volz
± 10.15 h.	Premiere of the Dutch film "Predetermined Time Systems"
± 11.00 h.	Formation of sections for the 2nd day and opportunity to make further acquaintance while enjoying a cup of coffee
11.45 h.	Official reception at the City Hall by the Municipality of the Hague
13.00 h.	Luncheon in the Kurhaus
14.15 h.	Excursion to the Keukenhof, the bulb-fields and the North Sea Coast
± 19.00 h.	Arrival back at the Kurhaus

Tuesday, 28th April 1959

To attain results with M.T.M., it is necessary to go in smaller groups into the details of the subject.
To get acquainted with each other and to make lasting contacts it is necessary to see a person at work.
These two reasons have led the Board to decide to fix the second day of the Conference for discussions in separate small sections, which will be the guests of various companies.

The following are under consideration:

1 chemical industry
2 ready-made clothing industry
3 electric equipment industry
4 printing
5 office organization
6 metalware industry

7 engineering works
8 maintenance service and repair shop
9 shoe industry
10 textile industry
11 horticulture
12 packaging (of products)

while attention will be paid to possible new suggestions for any other sections made on the application form. Of the discussions in the sections a short report will be given on the third day, while a full report will appear afterwards in the Conference Proceedings.
Depending on the number of ladies participating in the Conference, a "Ladies'-programme" will be set up for the 28th April on behalf of the foreign and Dutch ladies.

Wednesday, 29th April 1959

9.30 h.	Re-opening of the plenary session by the President of the Nederlands M.T.M.-Genootschap, mr ir R.F. Volz
10.00 h.	Discourse and treatment of case-histories and special studies; including contributions by foreign participants (coffee from 10.45-11.15 a.m.)
12.30 h.	Luncheon
14.00 h.	Continuation of the morning session and reports of the discussions in the sections
17.00 h.	Closure
17.30 h.	Assembly in the Kurhaus for appetizer and a cold buffet.

N.B. In any case on 29th April, but when possible in all plenary sessions, a simultaneous translation system and interpreters will be present.

Thursday, 30th April 1959

The greatest enemy of the Netherlands is the water; down the ages they have fought it and at last conquered. The Board will spend the fourth and last Conference day, besides in consolidating the contacts already made, in showing you our latest big works, viz. the storm-sluices at Krimpen a/d IJssel and the Delta-plan.

Departure	10.00 a.m.	from the Kurhaus Scheveningen
Back	17.00 p.m.	at the Kurhaus Scheveningen

APPLICATION I

MTM STANDARDS FOR MULTI-PLANT OPERATION

by

E. W. Sloan
Schnadig Corporation

When we were first approached about making an appearance before this group we were a little hesitant about choosing the subject matter. We finally decided to go into the phase of MTM problems encountered in our type of operation rather than a specific set of MTM data because we feel we have a different approach in establishing standards in our multiplant operations. It is necessary to give you a short description of our operations in order for you to better visualize the scope of the problem.

The Schnadig Corporation, which has two divisions - International Furniture and Karpen Furniture - is generally recognized as the second largest manufacturer of upholstered furniture in the United States.

We have upholstery plants in Pennsylvania, Georgia, Texas, California, and Indiana. These five plants, as well as two raw lumber mills, are serviced from a centrally located Engineering Department in Rushville, Indiana.

As many of you may know, our industry is highly competitive with complete new style introductions four times a year. In order for us to establish accurate costs in a minimum time and for the required volume it was necessary to have a dependable tool to work with. Our management selected MTM as this tool approximately five years ago. Until just recently, the entire furniture industry had gone along for the past 100 years without any real emphasis on methods improvements. We, along with several of our competitors, decided that if we were to continue a profitable operation we had to pinpoint the methods in use and also continually strive to better them. This attitude has been reflected in many revolutionary methods changes within the past five years. I mention this only to point out that we are relatively new in the field of methods improvements in relation to some of the industries you people represent. To get back to our operation, Engineering's role can be summarized briefly as follows.

The Merchandising Department sends us sketches of proposed new styles, our engineering design development people translate these sketches into actual pieces of furniture. In the meantime our methods and materials engineers are establishing labor and material specifications, top management merchandising people review the sample furniture in terms of customer appeal, at its now determined cost. They either reject it, or accept it - generally subject to additional modifications. A review with subsequent revisions may be necessary two or three times before the finalized new introductions are ready to show at one of the four furniture markets. Labor and material specifications keep up with the changing samples, and shortly after the market, the final labor rates and material specifications are issued to all five of our upholstery plants.

This has been a general description of the development and engineering of new furniture designs. Now, to be a little more specific in the methods department. We have the following main direct labor departments to service - cover cutting and marking, sewing, frame assembly, springing, upholstery, panel making, finishing, and cushion stuffing and closing. We have MTM standard data developed and working efficiently for all areas except cover cutting, springing and finishing. These excepted areas are all in some stage of completion at the present time.

Please bear in mind our standard data development build-up is relatively slow in comparison to a metal working or assembly type plant. The main reasons for this are: (1) the determination of standards methods which are applicable to the personalized techniques used in upholstery; (2) the exceedingly high number of variables which must be included in order to insure our data will remain usable for a long period of time; and (3) the relatively long cycle of our operations (up to an hour and a half in many cases).

To illustrate the number of variables we have in a set of data, I have passed out a copy of our panel work sheets. (Panel Work Sheet Follows Text.) You can see the panel is a very

small part of the finished piece, but there was a considerable amount of time spent developing the data. We are now able to establish permanent rates in the majority of the departments in advance of beginning production and do it without having to use highly skilled engineers for the actual rate setting. In fact, we have only three people setting labor rates and in the first eight months of this year they had issued to the plants more than 20,000 different individual incentive labor rates. We therefore feel that our MTM standard data has certainly done what our top management expected. We also feel that there is a definite cost savings in the Engineering department by having it centralized with a relatively small staff as compared to having engineering departments in each of our five plants doing duplicate work.

We do have problems, and I will go into them in some detail and tell how we are solving them.

Our No. 1 problem is certainly no surprise to most of you. I call it, "Methods Policing" or "Maintaining Standard Methods". I'm sure it is a serious problem encountered in practically all industries, using any type of incentive system. In our particular operation, however, there are a number of compounding factors that make it a real headache. First of all, we do not have the engineering manpower, nor do we feel it would be economically feasible to have a large enough staff, to furnish a detailed methods description for the huge volume of rates we issue. (I mentioned earlier there were approximately 20,000 rates issued the first eight months of this year.) We have to rely, therefore, on historical methods used for similar operations and standard method write-ups which apply for a wide variety of methods. Of course, we do send out detailed methods descriptions for any new operation, material, or equipment being used. You can readily see, however, that this system can lead to misunderstanding in some of our plants as to the method we are paying for. This is a really important factor because our whole MTM system is based on paying for the specified method. It is important that our factory management periodically review our standard data methods so that they have a personal knowledge of standard methods.

Another factor contributing to this problem is that we do not have any "policeman" in the form of an engineer at any of our plants. I should say we had none because we recently acquired, by transfer from Plant Supervision, a very capable man for our second largest plant. He has only recently completed the 105-hour MTM training course. In time he will be able to properly "police" methods and process incentive grievances on a local level. Still another factor is the difference of opinion among our plant managers as to what is necessary to maintain a high quality product. This may result in material or labor deviations which may not find their way to the Engineering Department. For these reasons you can see why the "method policing" is so important in a multiplant operation.

Although there is a definite tie-in with "Standard Methods," I will treat "Standard Plant Layout" as another specific problem. With five different sets of physical facilities, it is a tremendous task to keep even the general flow of materials running the same way. When it gets down to departmental level there is a tendency for line supervision to "upset" the standard layout and therefore if not controlled there could be as many as five different layouts. It is imperative that the layout <u>not</u> be revised without full approval of the Methods and Standards department. This is just normal, basic, Industrial Engineering philosophy, but, again, sometimes difficult to police. We set our data for the best layouts. These occasionally may be difficult to set up in all plants. Again, MTM may be unjustly accused for alleged rate inequities if the standard layout is not maintained.

Our third and most serious problem is common to all multi-plant operation and also to most single plant operations. It is that mutual problem of adequate "communication". Most of you know that when you get an incentive grievance it ordinarily doesn't contain nearly enough information to determine the basic cause without going to the department involved. Perhaps you can imagine, then, why we sometimes have to have two or three written exchanges with our various plants before we know we're talking about the same specific complaint. This problem in communications is one we <u>do not</u> have "licked". We seriously doubt if <u>anyone</u> has.

These have been the main problem areas we have encountered. Of course, there are many others, but they will generally fit into one of the categories I've mentioned. I'd like to take a little time now to discuss some of the steps we are taking to alleviate these problems.

In the matter of "Methods Policing" - I mentioned earlier we were not able to send complete methods descriptions with all rates.

However, we are now asking each plant to petition us for a methods description of any operation in which there is any doubt as to the approved method. I also mentioned we have a resident engineer in one of our plants. Eventually we are planning to have one in each of our other plants. Please note he will not set rates, but only police methods, materials, and layout and assist in handling grievances. Until we get our resident engineer, we continue to barrage our plant managers with requests for any changes they have made. By giving them more information on MTM and how changed methods are reflected in the rates, we believe they are swinging more and more our way in reporting any deviations.

We are considering the introduction of "Work Simplification" course to further make plant personnel more methods conscious. In the area of Plant Layout there is little we can economically do to existing facilities. Our company is constantly expanding, and with each expansion we feel we get a little closer to standardized layouts. Our two largest plants have both had major layout changes within the past year which have helped considerably in this area.

I mentioned the communication problem. We are attempting to minimize this by a more complete grievance complaint description when it is originally submitted. We devised a form which, if properly filled in, will greatly expedite our grievance handling. Unfortunately, I can't report that this form has been an unqualified success. Some of our plant personnel are a little resistant to change. I think this is only a temporary condition, that will be resolved in a short time.

The problems I have given you are by no means inherent with only an MTM system. Since we use MTM almost exclusively, one of the upholstery unions has seen fit to use "MTM" as a "whipping boy". This brings me to a fourth problem which <u>is</u> brought about by MTM.

The UIU has recently made very bitter attacks against the use of MTM in the furniture industry. In case some of you haven't seen their journal, here are some of the choice things said about MTM:

1. MTM exploits the workers and chisels their earnings.
2. MTM is not scientific and not accepted by Industrial Engineers.
3. MTM is a guesswork system.
4. MTM claims to be the only right way.
5. MTM data is all based on a drill press operator supplemented by some data from a few other manufacturing machines and some assembly work. Therefore, it cannot be applicable to upholstery.

There are many more similar type accusations contained in their smear attacks but all are equally as ridiculous in nature.

We don't know if this is the birth of a union movement which will spread to other industries. I don't know how you feel about the subject, but we are ready to defend a system in which we firmly believe.

Here is how our company interprets this latest attack:

1. We feel the attacks are made because MTM ties the method down enough that good MTM rates are difficult to beat in arbitration.
2. That the unions are grieving against all incentive systems because the majority of their arguments would make just as much sense against any other known system of incentive.
3. They may be just beating the drums because this has been a rather weak year for the furniture industry and they feel the people are more receptive to their exaggerated criticisms when they have smaller pay checks.

We are, however, attempting to expose all our line supervision to a short course in MTM so that they can help "carry the ball" in defense of our system. We are even inviting union personnel to attend classes if they wish.

To summarize, we at the Schnadig Corporation believe a multi-plant operation can be serviced with a centrally located Engineering Department by use of MTM Standard Data if the areas of Methods Policing, Standard Layout, and Communications can be successfully handled. We feel we are succeeding in minimizing these areas and have a workable, efficient system.

APPLICATION I

SCHNADIG CORPORATION

SECTION 5. -- PANEL DEPARTMENT
Work Sheet

Date________________

Engineer________________

Style No. ________________

Piece ________________

Type ________________

Sketch

Sequence Number	Description	TMU Sub Total	TMU Total
1.	Unroll and tear cotton to panel length - See table p-1		
2.	Pick up and move base to work area From table p-1 0 - 18" long Over 18" long Note: Do not use this element for bases without cotton	 53@ 66@	
3.	Pick up and move cotton to work area - From table p-2	64	
4.	Start and split cotton if necessary - See table p-3		
5.	Position cotton to base - See table p-4		
6.	Staple cotton to base. (Allow 1 staple/12 sq. inches, plus one per corners on bases over 2" wide, allow 1 per end on bases less than 2" wide) A. Pick up and aside staples. From General table N = Number of panels worked on at a time B. Align and staple cotton. See table p-5 Code _________ . _________ staples at _____ TMU/staple	77/N	
7.	Tear waste cotton from end and aside = See table p-6 Note: Allow cotton to be torn from each end of each base.		
8.	Cut and aside waste cotton if necessary. See table p-7 Note: Divide values by number of panels covered by one cut.		

APPLICATION I

Sequence Number		TMU Sub Total	Total
9.	Aside cotton covered bases to temporary storage From Table P-2	39	
10.	Obtain and move covers and position to work area See Table P-8		
11.	Pick up and move base and position to cover. From Table P-2 A. Bases without cotton 1. 0-18" Long 2. Over 18" Long B. Bases with cotton 1. 0-18" Long 2. Over 18" Long	 53@ 66@ 68@ 73@	
12.	Reposition base to cover - See Table P-9		
13.	Pick up and aside stapler. Align first end of cover. Stretch cover opposite end. See Table P-10		
14.	Staple both ends of cover (straight) . Code ______.________inches @____________TMU/inch See Table P-11 for Code description and values		
15.	Fold, pull, staple, and inspect corners See Ta le P-11 Code ______.________Corners (omit inside corners) @ ________________TMU/corner.		
16.	Obtain and aside shears and make relief cuts if necessary See Table P-12.		

Sequence Number		TMU Sub Total	TMU Total
17.	Staple sides or curved ends. Code ____________ ________ inches not stretched @________TMU/inch ________ inches stretched with hands, regulator @ ________ TMU/inch ________ inches stretched concave curves @ ________ TMU/inch ________ inches stretched convex curves @ ________TMU/inch ________ inches corner reliefs @________TMU/corner Use Table P-11 to determine code to use and TMU values per inch. Note: Care must be taken in this element that a proper analysis is made of stapling requirements for ea panel		
18.	Obtain and aside shears and make identity relief cuts if panel is less than 1-1/2" wide A. Panels 0-1" wide - from Table P-13 B. Panels 1" to 1-1/2" wide - from Table P-13	 211 144	
19.	Obtain and aside chalk, pen or crayon and make panel identification number and operators identification number. From Table P-14	134	134
20.	Pick up and aside shears and trim off excess cover From Table P-15	66	66
21.	Turn finished panel over, physically inspect for tightness and aside. See Table P-16		
22.	Visually inspect finished panels, break staples loose on cardboard bases with less than full thickness of cotton. A. Wood and meadboard bases and cardboard bases with full thickness cotton from Table P-17 ______ inches perimeter length at .8 TMU/inch ______ corners and seams at 7.3 TMU/corner or /seam ______ curves at 14.6 TMU/curve		

APPLICATION I

Sequence Number		TMU Sub Total	TMU Total
	B. Cardboard bases with less than full thickness of cotton. __________ inches perimeter length at 4.5 TMU/inch __________ corners and seams at 7.3 TMU/corner or seam __________ curves at 14.6 TMU/curve		
23.	Add following for panels with welt A. Obtain welt, cut off, strip and recover both ends position and staple both ends (include obtaining & asiding staples) See table p-18 B. Staple welt to panel See table p-18 Code __________. __________ inches at _____TMU/inch		
24.	Add following for curved panels requiring fixtures A. Position base and cover fixture. See table p-19		
25.	Add one of the following elements when cover is seamed. See table p-20 A. Spread seam and hold for stapling B. Spread seam and position base edge to seam	39	
26.	Add following when two or more bases are stapled together in one panel. Note: Allow 3" minimum. A. Position base to base, align and pull cover at joint, pick up and aside stapler See table p-21 B. Staple bases together 1. Meadboard bases - Code D. ______inches to be stapled @ 9.2 TMU/inch. From table p-11 2. Cardboard or wood bases - Code G. _____inches to be stapled @11.8 TMU/inch. From table p-11		

Sequence Number		TMU Sub Total	TMU Total
27.	Miscellaneous elements for special type panels. Add the ones which are applicable. All in table p-22 A. Rock base to staple cotton to semi-circular base. Allow 2.9 TMU/inch of outside edge length. B. Position base filler to base C. Open cover pocket for base D. Position base to cover pocket E. Roll up pair of panels in own tail. Allow 17.0 TMU/turn necessary/panel (turns calculated from length of tail and width of panel.) F. Panels requiring nails. 1. Obtain nails and aside overages 2. Obtain and aside hammer. Limited out by #1 3. Drive nails a. 1" nails 70.8 TMU/nail b. 1-1/4" nails 88.8 TMU/nail c. 1-1/2" nails 108.6 TMU/nail	 27 162 208 102	
28.	Attach job ticket to glue sheet. From general elements table.	80/ticket	80
29.	Other miscellaneous elements		

Total TMU	________
Total x 1.21 (allowances)	________
Total TMU allowed	________
Standards hours per piece	________
Standard hours per pair	________

TRAINING OPERATORS TO FOLLOW MTM METHODS

By

Miss Ginny Wonder
C. D. Osborn Company

I am greatly honored that you have asked me to be a speaker at this Seminar.

The subject I chose is, "How we applied our MTM knowledge into our training program."

I have always been interested in motion analysis, and better methods. When I heard about a three-week course in this subject, this was for me. I have always been a little leery when it came to rating our fastest operators. "If I could only use MTM, I would remove this mental block," I said to myself.

So I spoke to the President of our company, Mr. Henry G. Hartmann. He was sold on the idea, but he added: "Ginny, I will call and find out first whether you'll be accepted by the men in this field."

I was asked in class one day if the women didn't object to me. "On the contrary," I answered. "Women would rather be timed by another woman. They feel more at ease. Besides I never go to an operator and time her immediately."

First, I ask her permission. Second, I always make sure I compliment her in some way. Sometimes it may pertain to her clothes, her hair or her jewelry. I ask about the family, etc. Third, I am a good listener, so they confide in me and pour out all their troubles.

Believe me, when I say I don't dislike anybody, I'm there to help them, and down deep I know they feel the same way about me.

Another gentleman approached me in this fashion: "If you don't have any problems, why are you here?"

"Oh, we have a very serious problem," I answered. "Cost of living is rising. Our operators want more money for their output. The C. D. Osborn Co. can't raise the selling price of gloves. They have tough competition. The Japanese industry is undermining the American glove industry; this is our toughest competition. There is only one answer—Better Methods. Our training cost is sky high. It seems we train the girls for other needle work industries. From this course I intend to get the best methods for each job, and proper training for our new operators accordingly."

After the boys heard my point of view, and were convinced that I was there for a purpose, they accepted me and treated me as one of them. I completed the course successfully in 1953.

Upon my return to work, I sold Mr. Henry G. Hartmann the idea of holding one hour sessions twice a week. I became the instructress who familiarized our supervisors with MTM. I must have done a pretty good job for they all became MTM conscious and accept my MTM studies.

To get started on the right track, Mr. Drummond was asked to help me at the C. D. Osborn Co. for two weeks.

I decided to analyze our most difficult job first. This was sewing Inseam Fourchettes. "To get the best method for a job analyze your fastest operator," Mr. Drummond told me. "No doubt she is the highest earner and must employ the best methods for doing the job."

After watching the operator for one hour, and getting more and more confused with every motion, I almost gave up the idea. I didn't know what hand to watch, both were so fast I was getting dizzy. Mr. Drummond was in the same stage of confusion for he didn't have one motion listed. I looked at Mr. Drummond and said "Is it possible to MTM this job?"

"Yes, Ginny, but we have to do one thing at a time. First, we will analyze the right hand, forget the left hand completely. Then we'll analyze the left hand only. Only then can we start on both hands." It took us a whole week to analyze our first job. The most surprising thing was that we came out to exactly the same standard hours that were set by time studies years ago.

APPLICATION II

The second and third jobs became a little easier because I knew what to look for.

One day, Mr. H. G. Hartmann said, "We have the best methods listed on paper. Can we get our supervisor to train new operators with this method?"

In order to sell anything to anybody, you yourself have to be sold. So I sat down at the machine trying to follow this method. Believe me, I couldn't do it. I spent more time trying to match the right hand with the correct fourchette. I knew something was wrong. Mr. Carl Bracken, was told of my problem and with his help we came out with this training program which has been passed out to you gentlemen.

The training program was a full time job so we selected a very capable young girl. Ursula not only speaks a few languages but also has a very pleasant personality, which helps when you are learning a new job.

The first thing a newcomer had to be taught was:

(a) The difference between a right hand and left hand glove.

(b) The difference between the right side and wrong side of the material.

(c) The starting point of the right and left hand glove.

(d) This rule should be memorized:

(1) Thumb gouge next to operator start with index finger.

(2) Thumb gouge away from operator start with little finger.

After the instructor explains this and she knows the new operator understands, she is then ready for Exercise One. The new operator must reach the standard time allowed for this exercise before she is shown what to do for Exercise Two. A complete outline of the training exercise can be found following the text of this presentation.

We know after 8 to 12 hours of training if we can make an operator out of her. After the operator completes the exercises successfully, she is ready for production work.

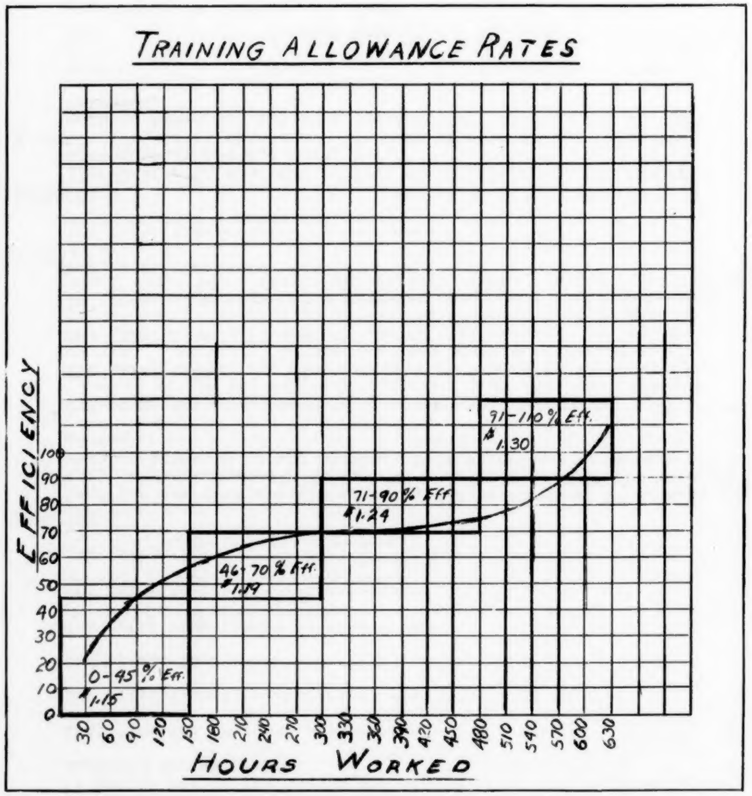
For each new operator we have a chart to watch her progress. This chart is reproduced on the following page.

We allow 630 hours or 15 to 16 weeks for opator to reach 110% efficiency. Before this training program we had allowed 32 to 53 weeks.

Keeping a chart for each new operator enables us to see how she is progressing. If the operator has fallen below our learner's curve, the instructor follows up the operator's motions with our MTM breakdown to see what she is doing wrong.

C. D. Osborn has been very successful with this new training program—thanks to MTM.

APPLICATION II



C. D. OSBORN CO.

TRAINEE PERFORMANCE RATING FORM

INSEAM FOURCHETTE SEWING

TRAINEE'S NAME ______________________ CLOCK NO.__________

DATE TRAINING STARTED ____________ DATE COMPLETED ____________

INSTRUCTOR ____________________________

It is important that the instructor inform the trainee of her results on each time trial of each exercise.

EXERCISE 1

Handling of glove only with the left hand from a mixed pile. Trainee picks up glove with left hand from a mixed pile 12" to her left. Identifies the glove as a left or right hand glove and drops the glove in front of her with the right side up. She identifies the glove to the instructor as a right or left hand glove during this exercise.

Std. time for 48 gloves---------

1st trial time------------------

2nd trial time------------------

3rd trial time------------------

4th trial time------------------

5th trial time------------------

EXERCISE 2

Exercise in handling both large and small fourchettes with right hand only. Trainee picks up 2 large fourchettes and places them right side up on the table. She then picks up 1 small fourchette and places this right side up on another pile. This is performed with the right hand only. This exercise consists of 96 large fourchettes and 48 small fourchettes.

Std. time for Exercise 2--------

1st trial time------------------

2nd trial time------------------

3rd trial time------------------

4th trial time------------------

5th trial time------------------

EXERCISE 3

Handling exercise in following the correct MTM handling procedure for the left hand in picking up the glove, identifying as left or right hand glove, and dropping right side up on table. Right hand picks up the first fourchette and the proper finger and fourchette is positioned to the needle and placed aside. This exercise is repeated for 48 gloves.

Std. time for Exercise 3----------

1st trial time--------------------

2nd trial time--------------------

3rd trial time--------------------

4th trial time--------------------

5th trial time--------------------

EXERCISE 4

Handling exercise exactly as performed in Exercise 3 but also the trainee simultaneously raises the presser foot with the knee press when positioning to the needle. This exercise is repeated for 48 gloves.

Std. time for Exercise 4--------------------------------48 gloves

1st trial time---------------------

2nd trial time---------------------

3rd trial time---------------------

4th trial time---------------------

5th trial time---------------------

EXERCISE 5

Instruction in name and purpose of machine parts and proper procedure to operate machine.

Step 1. Instructor points out the name of each of the following machine parts and explains the function of each part to the operator:

Head	Stand	Presser Bar Lifter
Arm	Presser Foot	Oil Cups
Bed	Treadle	Hand Wheel
Switch	Motor	Bobbin
Table	Feeder	

Step 2. The instructor next instructs the trainee in the correct procedure to operate the machine. The following points are emphasized:

Proper posture at machine

Raising the presser foot

Treadle for stopping and starting

Threading the needle

Tension

Exercise for the trainee in running the machine slowly (so she is able to count needle on downward stroke) so as to get the "feel" of the machine and better understand how it functions.

EXERCISE 6

Sewing exercises - Sewing straight vertical lines on Kraft paper without gauge or threaded needle. The trainee should be instructed to practice this exercise and attempt to sew on or as close to the marked lines on the paper as possible and then pick up speed after she has maintained her accuracy. This exercise is repeated until she (trainee) is ready to be timed.

Std. time for 1 sheet of Kraft Chart Paper-----------------------

1st trial time--------------------

2nd trial time--------------------

3rd trial time--------------------

4th trial time--------------------

5th trial time--------------------

EXERCISE 7

Sewing exercise - Stopping and starting without gauge or threaded needle on Kraft Chart Paper. Again accuracy in following lines and stopping and starting should be stressed by instructor before speed is developed.

Std. time for Exercise 7-----------1 sheet Kraft Chart Paper

1st trial time---------------------

2nd trial time---------------------

3rd trial time---------------------

4th trial time---------------------

5th trial time---------------------

EXERCISE 8

Sewing exercise - Sewing Fourchette patterns marked on Kraft Paper. Develop accuracy first and then pick up speed. This exercise is repeated at the judgment of the instructor until the trainee is ready to be timed.

Std. time for Exercise 8-------------------1 sheet Kraft Paper

1st trial time ------------------

2nd trial time ------------------

3rd trial time ------------------

4th trial time ------------------

5th trial time ------------------

EXERCISE 9

Sewing exercises - Sewing Nylon fabric fourchettes together using scrap buster material with threaded needle and gauge on machine. The trainee is instructed how to set gauge to machine and instructed to practice sewing seam on 2 fourchettes positioned together. This will follow the same outline of sewing as in exercise 8 except the operator will be sewing on material with threaded needle and gauge on machine. This exercise consists of sewing seam to 48 sets of fourchettes.

Std. time for sewing 48 sets of fourchettes---------------

1st trial time ------------------

2nd trial time ------------------

3rd trial time ------------------

4th trial time ------------------

5th trial time ------------------

EXERCISE 10

Sewing exercise - The trainee is instructed to practice sewing all the fourchettes to the glove following the same methods she will follow on production work. This is a job sample exercise except that she will be working on scrap or buster material. This exercise requires that the trainee follow the exact material handling and sewing methods which she has learned in the previous exercise and the method follows the MTM outlined procedure exactly. The instructor should allow the trainee to practice this exercise until the instructor feels she is ready for the timed trials. This is the most important exercise of the group and any errors should be immediately corrected by the instructor.

Std. time for Exercise 10 --------------------------------48 gloves

1st trial time ------------------

2nd trial time ------------------

3rd trial time ------------------

4th trial time ------------------

5th trial time ------------------

After the trainee has successfully completed this exercise she should be ready for production work and should be released to her regular supervisor for further production training and her production training chart starts at this point.

Instructor's Comments as to trainee's performance during preliminary training exercises-------------------------------

----

Instructor's Signature ---------------------------------------

APPLICATION III

AUDITING METHODS

By

EVAN DeJONG
Evansville Division of Whirlpool Corporation

Many of us come to seminars or meetings of this kind hoping that the lightning will strike as we hear some one develop their experience that will be exactly the information, plan or condition we wanted to learn about. This is perhaps the human way of looking at these situations. You perhaps know from experience that rarely do these things happen. Usually it is a tedious job of ferreting out an idea here and there that will fit and meet your needs.

If this discussion on Methods Audit will lend ideas and be of help, or build confidence, it certainly will have been gratifying for me to have made a small contribution toward better industrial engineering activity in your respective operations.

As I pointed out, this may not be "tailor-made" for you and, therefore, we should relate some of the background and conditions that were present during our project analysis so that you can properly bring this discussion into focus. Actually we had conditions that were in favor of a highly successful program.

The Whirlpool Corporation - Evansville Division, makes gas and electric refrigerators, upright freezers, air conditioners and dehumidifiers in both the RCA/Whirlpool line and the Coldspot line for Sears Roebuck. We also have a division making components for Aircraft.

The division, as it is now, was brought into being in 1955 by a merger between Whirlpool and Seeger Refrigerator Company, the range and air conditioning division of RCA; the purchase of the International Harvester Manufacturing facilities in early 1956; and the purchase of the Servel Manufacturing facilities and patents in early 1958.

The rapid expansion of course posed a terrific problem in integrating personnel, manufacturing facilities, and policies. Management men from three (3) different refrigerator manufacturing operations were brought together to develop, as quickly as possible, smooth operating manufacturing facilities. The concepts of line supervision, cost procedures, and industrial engineering, which are most important to this discussion, were varied according to the individuals' background.

Through the natural re-organization and press of getting new operations into production, some industrial engineering activities were not given the attention that is necessary for up-to-date application and administrative practices. These problems and others are pin-pointed when the great equalizer "competition" lets you know that your position is not firm. This is particularly true in our corporation where divisions compete against each other, and outside suppliers, to provide parts or components for any of the other divisions.

The problem was identified. We had to make a complete analysis of a basic component of a refrigerator unit to determine as quickly and accurately as possible what we could do to bring our costs down. A Methods Audit was a substantial part of this analysis.

In early September of last year, the Industrial Engineering Department held a meeting with the Plant Manager, and his key personnel, to explain the purpose of the cost analysis project and to determine the scope it should cover. Representatives of tooling, inspection, layout, processing, production control and product engineering also attended this meeting so that they could lend invaluable service as the various phases of the project were studied.

The project was outlined as follows:

1. We would analyze a unit which was representative of the majority of our production.

2. We would collectively determine the effectiveness of the use of our people, methods, tools, equipment, material, flow and work-place layouts as related to good sound costs.

3. We would conduct this analysis so as not

to incite labor problems by informing our employees, through our supervision, that we are about to embark on a Methods Audit of all operations of the component to determine to what extent our methods and work standards are outmoded and to what degree they have changed from the original installation.

4. We would use Methods-Time-Measurement (MTM) technique of measuring the effectiveness of methods and time standards.

5. We would use other appropriate industrial engineering tools and techniques toward achieving maximum effectiveness.

6. We would complete the survey part of the project by early November, 1957.

Beside outlining the project, time was taken in this general meeting to explain to the supervisory personnel something about MTM. None of these men had had MTM training but a few had received training more than fifteen years ago in the A. B. Segur system - M. T. A. This helped us to explain the background and concepts of MTM—at least to explain MTM as motion analysis, not time analysis. Admittedly, this could not be called orientation in the technique but it removed the possible mystery of the name and demonstrated the approach to be used on operation analysis. We were pleased with the generation of confidence that was apparent even in this short period of time.

To accomplish the assignment in the period allowed, a task force group was organized as follows:

1. Two (2) Industrial Engineers were assigned to make flow process charts of each of the (32) parts or sub-assemblies to determine the routing, handling, rework, etc. Simultaneously, possibility analyses were made to improve material utilization, handling elimination or combination of work.

2. Two (2) Industrial Engineers were assigned to make MTM analyses on each of (250) operations to evaluate current methods and establish time for the present method.

3. One (1) Tool Engineer was assigned to evaluate the feeds and speeds used on the machining operations to make recommendation for present tools (better utilization) or more efficient tools.

All of these data were coordinated by the Industrial Engineering Department and a summary analysis or recap sheet (See Chart I. All Charts follow the text) was made on each part or assembly listing each operation and the following information:

1. Time value for the original method.

2. Time value for the current method or with minor improvements of the work place area (combinations in some cases were obtained by group balance).

3. Time value from proposed improved methods.

Drawing the summary sheets into one total gave us the potential cost reduction that could be made. The recommended changes told the brief story of what had to be done; and, from this composite picture, an approximate schedule could be set as a goal to put the project through to completion.

With the summarized audit information, a report containing the findings, conclusions and recommendations resulting from our survey was given to all members of management concerned with this activity so that they could see the total value of the project. In turn, these supervisors could encourage their people to work together in a spirit of cooperation and unity with a common goal and purpose in mind to obtain maximum realization of the cost reduction potential.

An important factor that warrants emphasis is that all of management was aware of a project of this kind. In this way, continual progress must be made by all groups contributing their efforts. Obviously, when your supervisor is interested in a project, the results will be forthcoming. This kind of attention is healthy.

FINDINGS

The results of the audit or survey potential (see Chart II) indicated we were 48% over in direct labor and 75% in inspection. ("Over" being the relationship to final position of the goal with methods improvement and up-to-date standards.)

The reason for these differences can be related to a number of different conditions, concepts, procedures and administration practices. Specifically, the Industrial Engineering problems

can be summarized as follows:

1. Some of the standards were not set with good practices.

2. The Industrial Engineering Department did not keep up with methods, layout and process changes with the speed and follow-up that is necessary to maintain cost control.

RECOMMENDATIONS

The recommendations that we made after an analysis of the problem included the background which gave reason to some of these conditions were as follows:

1. To set up a procedure that would give closer coordination with the cost department on up-to-date labor standards and keep them informed of changes.

2. To set up a supervisory training program based on what part the supervisors play in developing a work standard; how it is done; how it is controlled; how it is administered; and what concepts must be used to produce a competitive profitable product.

3. To immediately begin a program of final analysis of methods, tools, equipment and work standards for the purpose of bringing them up-to-date.

4. To analyze inspection methods and measure that part of inspection that is necessary so that these costs may be brought into proper range.

Each of these recommendations can be discussed at length but for purposes of this discussion and the part MTM played, I would like to deal at some length with Items #3 and #4.

HOW WAS THE INSTALLATION HANDLED?

The most immediate step was to bring standards up-to-date with the method that was found current during the audit. We did use MTM to a great extent in knowing what the new standard should be. However, because MTM was somewhat unfamiliar to foreman and operators, it was not used as the only basis for time standards. We actually timed the job where methods had changed and/or been revised to establish the new standard. Group operations were also time studied and rebalanced according to the amount of the methods changes made. In some cases, these efficiencies were not realized until a production level change increased or decreased the number of people.

The MTM analyses were valuable in having good leveled time for making an operation combination by man and machine charts. The MTM studies showed a more effective burring and wire brushing method. Also, close analysis of the operator holding the clamp indicated the necessity could be eliminated with a minor tool change. The result, we were able to show an effective combination to the foreman, and in advance of the change, tell him what the result would be. (See Charts III & IV.) This was particularly helpful because no standard data was available to help in predicting operation time for new methods.

MTM also improved the effectiveness of flow process charts. It was determined from a flow chart analysis that two different valves were used during the processing of the unit—one at the plant making the assembly, and one at the plant putting the assembly into a refrigerator unit. This is shown by the random selections of operation for illustrative purposes on Charts V & VI.

With the use of MTM, we were able to estimate the new operations that would be involved if a common valve were used. A cost reduction report (see Chart VII) was prepared to show the cost differential of the present and proposed method. In this case, valid data was very important because of the substantial sum of money required to tool and change the process equipment. Management could see the results and be in a position to authorize the expenditure necessary to put the cost reduction proposal into effect.

The methods audit was not the only approach to cost reduction. There was, and is, an effective committee composed of key staff personnel from the engineering and cost departments. This group is headed by the Chief Product Engineer for the component we were to audit. This gave us an effective hand in getting improvements installed if product design was involved. Further, with the new data being generated, we would lend valuable assistance to them in evaluating proposed changes as they were considered within the committee.

In each of the examples I have used to show you how the installation was made, MTM had a key part in making methods improvement and cost

reductions. It might be termed the vehicle for getting other good industrial engineering techniques rolling and into full use.

The result of the program was most gratifying. This can be seen by Chart VIII. Our objective has been reached. The majority of the improvement being made in four (4) months. Further, the Chart does not reflect improvement in design for quality and performance that were absorbed during this program.

An important factor that warrants mention is - This program was put into effect without an appreciable amount of supervisory or employee objection and unrest. It was done with good communications, fairly and appropriately. We approached this problem with the concept that we would use good sound Industrial Engineering and Management principles in obtaining maximum effectiveness from men, materials and facilities.

APPLICATION III

CHART I

ASSEMBLY RECAP SHEET

OPER NO	OPER. DESCRIPTION	ORIGINAL METHOD TMU	CURRENT METHOD MTM AUDIT TMU	PROPOSED IMPROVED METHOD TMU	RECOMMENDED CHANGES
2	MATCH PARTS FRONT HEAD, REAR HEAD CYLINDER & ROTOR ASSY	800.0	550.0	550.0	COMBINE OPERATION
4	BURR CYLINDER & FRONT HEAD BORE	488.3	250.0	0	ELIMINATE
6	OIL ROTOR	166.6	135.5	0	AUTOMATICALLY OIL
8	ASSEMBLE STATOR LEADS	983.3	686.6	686.6	IMPROVED METHOD
10	WELD SERIAL PLATE & UNLOAD CONVEYOR	650.0	400.0	400 0	CHANGE SEQUENCE & COMBINE

CHART II

TOTAL COMPARISON SURVEY POTENTIAL

TYPE LABOR	ACTUAL POSITION IN % OF GOAL AT START OF PROGRAM	PROPOSED POSITION IN % OF GOAL WITH PROPER STANDARDS	FINAL POSITION IN % OF GOAL WITH METHOD IMPROVEMENTS
DIRECT	148%	116%	100%
INSPECTION	175%	130%	100%

CHART III

6S-318

Whirlpool CORPORATION
EVANSVILLE DIVISION

MULTIPLE ACTIVITY CHART

INDUSTRIAL ENGINEERING DEPARTMENT

PART NO. 41768 PART NAME REAR HEAD
OPER. NO. (8) (10) OPER. DESCR. BURR & WIRE BRUSH FACE & FORM VALVE SEAT
MACH. NO. ______ TYPE HEALD BOREMATIC
DEPT. 111 SHOP ____ LINE ____ OPER. REV. DATE 11-27-57
INVESTIGATED BY E. MASON DEPT. 791
DATE 10-15-57

LAYOUT
PART CONVEYOR
OPER 10 — BURR BENCH
OPER 8 — BOREMATIC

ACTIVITY OF OPERATOR OPERATION #8	TIME UNIT	ACTIVITY OF OPERATOR OPER #10	MACHINE
BURR (4) BOLT HOLES, (1) SLOT & CHECK VALVE RELIEF HOLE .15 / .15	.05	LOAD & UNLOAD BOREMATIC .07	IDLE (LOAD UNLOAD) .07
	.10	DISPOSE & OBTAIN PART .10 / .03	
	.15	OPERATOR HOLD CLAMP .226 / .126	FACE & FORM VALVE SEAT .156
WIRE BRUSH SUCTION HOLE, OIL RELIEF HOLE .11 / .26	.20		
	.25	TOOL CHANGE STOCK HANDLING MISC. ELEMENTS .266 / .04	IDLE
STOCK HANDLING MISC. ELEMENTS .04 / .30	.30		
	.35		

CHART IV

68-318

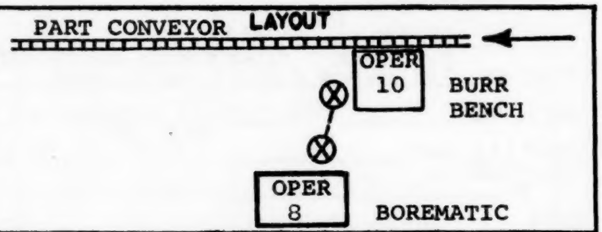
Whirlpool CORPORATION
EVANSVILLE DIVISION

MULTIPLE ACTIVITY CHART

INDUSTRIAL ENGINEERING DEPARTMENT

PART NO. 41768 PART NAME REAR HEAD
OPER. NO. 8 OPER DESCR. FACE & FORM VALVE SEAT BURR & WIRE BRUSH
MACH. NO. ______ TYPE HEALD BOREMATIC
DEPT. 111 SHOP ____ LINE ______ OPER. REV. DATE 11-27-57
INVESTIGATED BY E. MASON DEPT. 791
DATE 11-27-57

LAYOUT



ACTIVITY OF OPERATOR OPERATION #8			TIME UNIT	ACTIVITY OF MACHINE		
BURR (4) BOLT HOLES (1) SLOT & CHECK VALVE RELIEF HOLE	.12	.12	.05 .10 .15	FACE & FORM VALVE SEAT	.156	.156
WIRE BRUSH SUCTION HOLE, OIL RELIEF HOLE	.10	.22	.20	IDLE	.22	.064
LOAD & UNLOAD BORE MATIC	.08	.30	.25 .30	IDLE LOAD UNLOAD	.30	.08
STOCK HANDLING TOOL CHANGE MISC. ELEMENTS	.05	.35	.35			

APPLICATION III

CHART V

68-317

Whirlpool CORPORATION

EVANSVILLE DIVISION

Sheet ____ of ____

FLOW PROCESS CHART

Part Name COMPRESSOR ASSEMBLY — Part Number 457805

Operation Description ASSEMBLE & BRAZE — Operation Number

Equipment or Machine Type — Machine

Dept 113 Line — Proc. Sheet — Issue

Investigated by — Date

Start Point ASSEMBLE ROOM — End Point PLANT #2

Subject Charted

SUMMARY

METHOD	Present	Proposed	Saving
Operations ○	31		
Transportations ∘	40		
Storages △	8		
Inspections □	5		
Man Hrs. or Minutes			
Distance Traveled	1443'		

DETAIL DESCRIPTION PRESENT / PROPOSED	SYMBOL	Distance	Time	What?	Where?	When?	Who?	How?	NOTES	Eliminate	Combine	Chg. Sequence	Simplify
1 REC'D FROM LAST OPERATION													
2 INSPECT FOR GROUND													
3 MOVE													
4 ASSEMBLE PLUG ASSEMBLY									WITH #6				
5 MOVE													
6 TIGHTEN CAP ASS'Y SPRING									WITH #4				
7 MOVE TO SECOND FLOOR													
8 PLACE DISCHARGE & CHG. TUBE									NOTE: RANDOM SELECTION OF OPERATIONS				
9 MOVE													
10 PLACE FLARE NUT & SOLDER JOINT													
11 MOVE													
12 SOLDER SUCTION TUBE & FUSE END													
13 MOVE													
14 POSITION OIL DISCHARGE TUBE									CHANGE DESIGN				
15 MOVE													
16 SOL. OIL DISC. TUBE & FUSE END									CHANGE DESIGN				
17 MOVE													
18 FUSE 2 TUBE ENDS									CHANGE PROCESS				
19 MOVE													
20 ASSEMBLE CHARGING VALVE									PLANT #1 VALVE				
21 MOVE													
22 TIGHTEN VALVE & CHARGE													
23 MOVE													
24 INSPECT - LEAKS													
25 MOVE													
26 DEHYDRATION OF COMP.													
27 MOVE													
28 REMOVE VALVE & ASSEM NUT									PLANT #1 VALVE				
29 MOVE									USE COMMON VALVE				
30 PAINT													
31 MOVE TO PLANT #2													
32 REMOVE PLUG & ASSEM VALVE									PLANT #2 VALVE				
33 MOVE									USE COMMON VALVE				
34 BREAK TUBE ENDS													

CHART VI

6S-317

Whirlpool CORPORATION
EVANSVILLE DIVISION

Sheet ____ of ____

FLOW PROCESS CHART

Part Name COMPRESSOR ASSEMBLY   Part Number 457805
Operation Description ASSEMBLE & BRAZE   Operation Number ____
Equipment or Machine Type ____   Machine ____
Dept 113 Line ____ Proc. Sheet ____ Issue ____
Investigated by ____ Date ____
Start Point ASSEMBLY ROOM   End Point PLANT #2
Subject Charted ____

SUMMARY			
METHOD	Present	Proposed	Saving
Operations ○	31	23	8
Transportations ∘	40	28	12
Storages △	8	8	
Inspections □	5	2	3
Man Hrs. or Minutes			
Distance Traveled	1443	1443	

DETAIL DESCRIPTION PROPOSED	SYMBOL	Distance	Time	What?	Where?	When?	Who?	How?	NOTES	Eliminate	Combine	Chg. Sequence	Simplify
1 REC'D FROM LAST OPERATION	○ ∘ △ □												
2 INSPECT FOR GROUND	○ ∘ △ □												
3 MOVE	○ ∘ △ □												
4 ASSEMBLE PLUG ASSEMBLY	○ ∘ △ □												
5 MOVE TO SECOND FLOOR	○ ∘ △ □								CONVEYOR				
6 POSITION DISCHARGE & CHG. TUBE	○ ∘ △ □												
7 MOVE	○ ∘ △ □												
8 PLACE FLARE NUT & SOLDER JOINT	○ ∘ △ □								NOTE:				
9 MOVE	○ ∘ △ □								RANDOM SELECTION				
10 PLACE FLARE NUT & SOLDER JOINT	○ ∘ △ □								OF OPERATIONS				
11 MOVE	○ ∘ △ □												
12 SOLDER SUCTION TUBE & FUSE END	○ ∘ △ □												
13 MOVE	○ ∘ △ □												
14 ASSEMBLE CHARGING VALVE	○ ∘ △ □												
15 MOVE	○ ∘ △ □												
16 TIGHTEN VALVE & CHARGE	○ ∘ △ □												
17 MOVE	○ ∘ △ □												
18 INSPECT - LEAKS	○ ∘ △ □												
19 MOVE	○ ∘ △ □												
20 DEHYDRATION	○ ∘ △ □												
21 MOVE	○ ∘ △ □												
22 PAINT	○ ∘ △ □												
23 MOVE TO PLANT #2	○ ∘ △ □												
24 BREAK TUBE ENDS	○ ∘ △ □												
25	○ ∘ △ □												
26	○ ∘ △ □												
27	○ ∘ △ □												
28	○ ∘ △ □												
29	○ ∘ △ □												
30	○ ∘ △ □												
31	○ ∘ △ □												
32	○ ∘ △ □												
33	○ ∘ △ □												
34	○ ∘ △ □												

CHART VII

COST REDUCTION REPORT

FORM VUB-9007 DATE:

PART NUMBER	PART NAME	PROJECT NO.
ALL	COMPRESSOR ASSEMBLY	7-C113-7 REVISED
OPERATION NO.	OPERATION DESCRIPTION	DEPT. NO.
	ASSEMBLE & REMOVE CHARGING VALVE IN PLANTS 1 - 2	113

COMPARISON

PLANT #1 PRESENT METHOD		PLANT #1 PROPOSED METHOD	
REMOVE PLUG	.26 MIN.		
ASSEMBLE PLANT #1 VALVE	.26 MIN.	ASSEMBLE PLANT #2 VALVE	.26 MIN.
ASSEMBLE CONNECTOR & CHARGE	.26 MIN.	CHARGE WITH AIR	.26 MIN.
REMOVE PLANT #1 VALVE	.26 MIN.	REPAIR PLANT #2 VALVE	.35 MIN.
POSITION PLUG IN TUBE	.26 MIN.		
REPAIR PLANT #1 VALVE	1.10 MIN.		
PLANT #2		PLANT #2	
REMOVE PLUG & ASSEMBLE PLANT #2 VALVE	.36 MIN.	OPERATIONS ELIMINATED	
		TOTAL	.87
REPAIR PLANT #2 VALVE	.35 MIN.		
TOTAL	3.11 MIN.		

COST OF OPERATION INVOLVED	DOLLARS PER UNIT	COST OF OPERATION INVOLVED	DOLLARS PER UNIT
LABOR 3.11 x .031	.0964	LABOR .87 x .031	.0269
MATERIAL		MATERIAL "O" RING	.0080
MISC. 100% BURDEN	.0964	MISC. 100% BURDEN	.0269
TOTAL	.1928	TOTAL	.0618

ESTIMATED COST OF CHANGE		EST. BY	ESTIMATED SAVINGS	
TOOLING OR FIXTURES	$		SAVINGS PER UNIT	$.131
MACHINE OR EQUIPMENT	$		EST. ANNUAL UNITS	500,000
PERISHABLE TOOLS	$		EST. ANNUAL SAVINGS	$ 65,500
INSTALLATION	$		LESS COST OF CHANGE	$ 25,000
REARRANGEMENT	$		NET SAVINGS FIRST YEAR	$ 40,500
SURPLUS MATERIAL LOSS	$			
TOTAL COST	$		NEW METHOD WOULD PAY FOR ITSELF IN ____ YEARS.	

REMARKS: DUE TO THE VALVE STEM CLOSING IN DHYDRATION IT WAS NECESSARY TO ADD LABOR TO REMOVE STEM BEFORE OVENS & INSTALL AFTER. THEREFORE ACTUAL SAVING IS $57,000 OR 1.96 MIN.
THE CONDITION CAUSING THE ADDITION OF .26 MIN. IS BEING WORKED ON & WHEN THIS IS CORRECTED THE FULL SAVING WILL BE REALIZED.

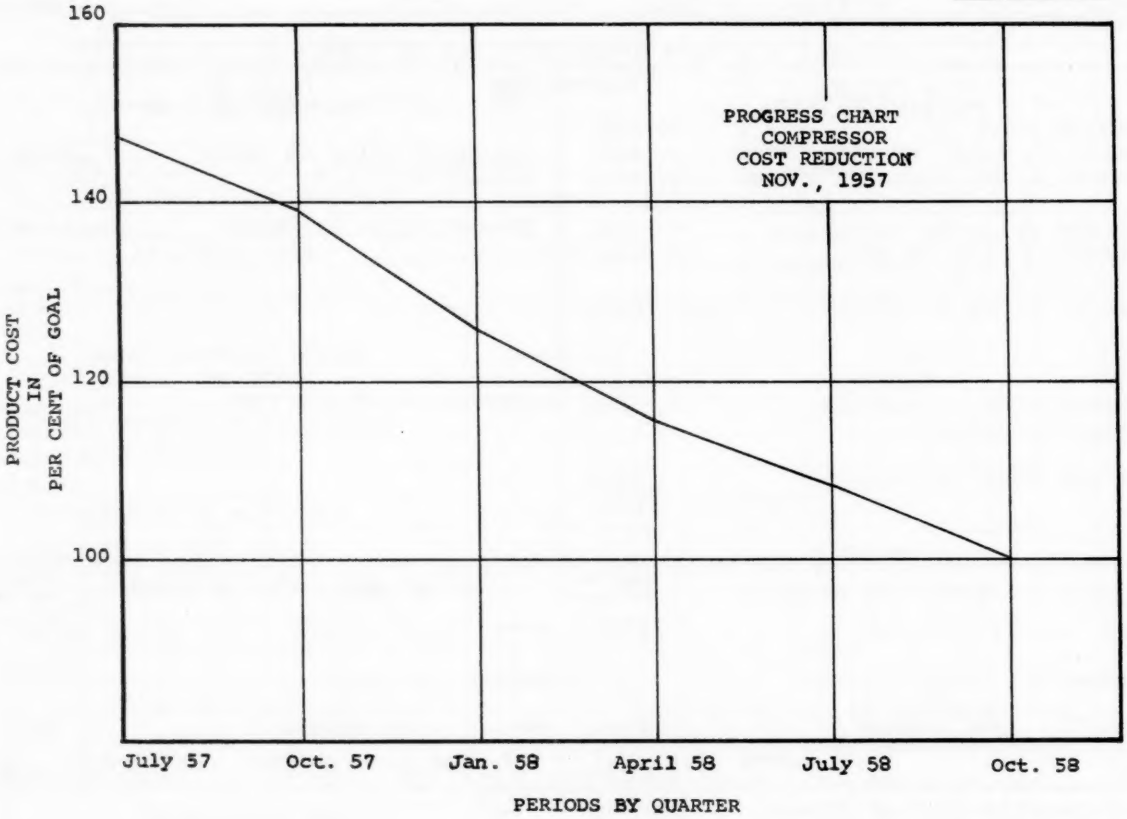
CHANGE SUGGESTED BY:
ANALYSIS PREPARED BY:
APPROVED I. E. DEPT.: R. K. MORRIS STANDARDS METHODS
ENCLOSURE
E. C. N. NO. ______
CAPITAL EQUIPMENT ☐

APPROVALS

SIGNED: ______ DATE: ______
SIGNED: ______ DATE: ______
SIGNED: ______ DATE: ______
SIGNED: ______ DATE: ______
SIGNED: ______ DATE: ______

APPLICATION III

CHART VIII



APPLICATION IV

DEVELOPING AN IMPROVED PLANT LAYOUT WITH MTM

By

Wayne Howart
Westclox Div. of General Time Corp.

The physical arrangement of manufacturing facilities to a large degree affects a company's ability to manufacture its products economically. The whole concept of processing and manufacturing control is reflected in the plant layout. The ultimate in cost reduction and cost control is to be achieved. Westclox management felt that in order to remain competitive a cost reduction plan was necessary. In the process of developing a plan for Westclox, it became apparent that an improved plant layout was a necessary part of the over-all program. Accordingly, a plant layout section was organized within the Industrial Engineering Department and a study was made to determine the best scheme of plant layout for Westclox.

The new plant layout was to accomplish two basic objectives:

1. To lower manufacturing costs through

   (a) Reduced material handling.

   (b) Improved methods and processing.

2. To determine the manufacturing facilities needed to meet a 10-year sales forecast.

In order to accomplish these objectives, the plant layout program was developed in terms of a four-phase study, designed to present a logical approach in developing the best plan of layout for Westclox. These phases of the study were as follows:

1. Space analysis.
2. Construction of block layouts.
3. Detailed department layouts.
4. Layout move sequence plan.

Phase 1 - Space Analysis

The determination of final space and equipment needs for a new layout is based on many separate analyses covering all aspects of manufacturing specifically, these analyses must lead to the answers to two basic questions.

1. How much space should be allocated to each department?
2. Where should each department be located to obtain best operating results?

In order to develop the answers to these two questions, a number of manufacturing conditions were analyzed individually.

1. Present space utilization - Department foremen were interviewed to determine specific space needs under current operating conditions and to evaluate the actual effective use of space. Each department was physically measured in order to assemble accurate space usage data. To supplement the foreman's interviews, personnel from the Plant Layout Section personally inspected each department in order to make an evaluation of space utilization. After the actual space needs under existing production were evaluated, the needs were projected to the ten-year figure.

2. Present equipment utilization - Equipment efficiency factors were developed with the aid of the Tabulating Section which prepared and processed special time cards. Operators and setup men were requested to stamp in and out these special time cards according to a predetermined list of conditions such as operating, setup, breakdown, no operator, no work, no raw material, etc. After a two-week period a summary of time cards permitted an efficiency schedule to be developed. In addition, this procedure pin-pointed equipment that was obsolete or not needed.

3. Personnel efficiencies - were determined by a detailed study of personnel efficiencies from Payroll statistics for a six-month period and an efficiency factor determined for the department. Efficiency factors were developed from a comparison of actual hours required for an operation against standard hours scheduled. These hours were totaled by department and a ratio of

total actual hours against total standard hours was the efficiency factor for the department.

Location Analysis

1. In order to analyze the direction and volume of the flow of material between departments and determine the best locations of departments, six representative clock models were selected and the movement of their individual parts from department to department was charted on input-output charts. The input-output charts were used to measure the amount of back tracking of material through the manufacturing processes. This tool provided the key to the best relative location of each department. The initial flow analysis indicated a 31% backflow of material. After a rearrangement of departments, backflow was reduced to 4.21% on the new layout.

2. Flow Process Charts by Model - In order to determine where manufacturing improvements could be made, each selected model was diagramed by means of flow process chart and reviewed to determine when individual operations could be (a) eliminated, (b) combined, (c) improved.

Phase 2 - Over-all Plant Layout

1. Plan No. 1 - The Ideal Layout. An ideal plant layout was constructed, independent of building restrictions or other considerations, to illustrate graphically the most desirable arrangement of the departments.

2. Restrictive Factors were then considered.

(a) Prohibitive cost because of the complexity of equipment installation in some departments. It was decided the cost was too great for relocation and the new plant layout would be designed around these departments.

(b) Floor loadings - The feasibility of moving heavy equipment into a multistory building was investigated and advised against placing heavy machinery in these buildings because of the floor load requirements. Cost would be great to reinforce the floors and a safety hazard created if the floor was overloaded near one of the large machines.

3. Three Basic Plans were submitted, each reflecting the:

(a) Flow Diagram.

(b) Significant Cost.

(c) Personnel Requirements.

Once the restrictions to a new plant layout were established, a series of alternate block layout plans were developed and evaluated. Three of the block layout schemes were completed and submitted for consideration. One of the three schemes was selected and, subject to minor modifications, was approved. The general concept of the layout is one of forward material flow and in-line processing.

Phase 3 - Departmental Layout

1. By product.

2. By process.

3. Repro-Templets.

After the first two phases of the program had been completed and the master block layout plan had been accepted, the next step was to develop the detailed arrangement of equipment for each department in accordance with the approved master block layout plan. The departments could be laid out by product or by process. After careful study of the departments, it was concluded that in most cases, a combination of the two methods was most logical. Repro-Templets were used in the actual layout work. These templets are to scale and indicate the outline of the various equipment. The templets have an adhesive back and are placed on an acetate grid sheet, in desired position. Working prints are then made from these acetate departmental layouts.

One of the departmental layouts which caused us great concern was the Shipping Department. We were faced with the problem of providing storage space for approximately 430 separate items totaling more than 2,000,000 units. From the beginning we realized we were faced with the problem of walking great distances for the items. The plant layout group worked closely with the MTM staff on this and together resolved a layout of flow racks, floor roller conveyors and overhead conveyor system, which runs the width of the storage area. This is supplemented by a traveling booster conveyor which carries picked items from the floor to the overhead conveyor.

The man picking the various items for the order selects the item from flow rack or floor conveyor. These racks are filled from the rear, the items roll forward, maintaining a constant

distance for the order picker to walk. Items picked for an order are placed on the conveyor and carried overhead. As the order is filled the picker will have traveled the width of the storage area. He then will take a new order and begin picking from the bottom of the order on the return trip. Since the new layout reduced the walking distance and maintained it as constant, the MTM Staff using predetermined times were able to establish standards for the department. Upon analyzing the new layout, we determined the personnel requirements to be 36 compared to 54 on the old layout, with possible further reduction in the force as experience with the system is gained.

Phase 4 - Move Sequence Plan

Phase 4 of the study was to develop the detailed plans and schedules for accomplishing the actual physical moves required by the new plant layout. The first step in this phase was to assemble all parties connected with the move and determine a leapfrog moving schedule. This schedule, in addition to giving a timetable of moving by departments, also reflected the costs of new buildings, any new equipment, and cost of moving itself. The actual physical moving required additional personnel in our Maintenance Department so these departments were immediately brought up to the estimated required figure. Once these remaining items were resolved, the actual move was under way.

APPLICATION V

ESTABLISHING METHODS AND STANDARDS WITH MTM

By

Lloyd M. Griffin
Shorewood Mills

I would like to take a few minutes to tell you a little about the Company I represent, in hopes you will better understand our experience with MTM. Shorewood Mills has been engaged in the manufacture of quality men's and boys' underwear for the past 39 years. Our production consists basically of Union Suits, Tee Shirts, Athletic Shirts, Shorts and Briefs made from a wide variety of fabrics. Through the necessity of customers' demands, we also make a number of items which are considered specialty items in our business and produce these on a job shop basis. The plant is located on the north side of Milwaukee, Wisconsin.

In recent years, the haphazard methods of the textile industry are undergoing a change. In more and more plants the proven methods of scientific engineering techniques and principles have shown increased productivity while costs go down. Some of the ways and means used successfully include:

- Improved Operator Training
- Better Job Breakdown
- Flow Charts
- Motion Study Using Motion Pictures
- Machine Improvements and Attachments
- Time Study and Others Including MTM in More Recent Years

Any of these techniques could be thought of as "tools" for the industrial engineer, which must be used correctly to be most effective. All have their duty in the problems of cost reduction.

Prior to my association with Shorewood Mills, work standards had been established by various people in the plant and occasionally some temporary outside help, with no records kept of how these standards were set up. It was decided to review these standards and set up a complete standards program with supporting records. After careful consideration of various methods available for this program, it was decided to use Methods-Time-Measurement procedure to bring these standards up to date and improve their accuracy.

A short comparison of Time Study versus MTM will help you to better understand the benefits of Methods-Time-Measurement to Shorewood Mills.

To obtain rate standards by Time Study, the industrial engineer has to determine the time required by an average, qualified and experienced operator to do a specific, standardized job at average incentive level.

Now the question arises, just who is an average, qualified and experienced operator? Such a person would be representative of our national industry's factory help in coordination, dexterity, reactions and general attitude. He has been carefully trained in the best method and has acquired enough experience at the job to perform comfortably and adequately.

The average factory may not have such a person. Even if there are piece rates, incentive pace may be lacking. In the sense, then, the operator in question may exist only in the imagination of the industrial engineer. This engineer must be thoroughly trained in the image of this operator. In addition, he must be fully capable of using the image of the worker at average incentive pace as a measuring rod for others.

We now face the question of what is the average incentive effort level. This is where a wide variation of opinion exists and many times a challenge is forthcoming from this point; however, there are statistical techniques which can assure reasonable accuracy for average effort within a given plant.

To be useful, Time Studies must be broken down to time for specific elements from which standard data can be built for future savings in rate work.

Unfortunately, data set by Time Study is weak in the following ways:

1. It takes considerable time to develop such

data complete enough to be used for setting rates.

2. It is difficult to find and observe the exact variations of method we need to time.

3. Short elements are difficult to time, especially with a stop watch.

4. It is almost impossible to describe the methods used in sufficient detail.

5. It is difficult to chart the elements for easy use.

6. Many elements are not interchangeable.

Let me hasten to add that even with its disadvantages, this type of data can be developed and used and it is being used with good results in many plants. The trouble is basically in the time needed to develop such data.

Some of the characteristics of the MTM technique which we feel to be valuable are these:

1. It requires a thorough and detailed analysis of the operation studied.

2. It provides a complete detailed, yet brief, description of method used.

3. It provides accepted time values of each motion used for the method analyzed.

We believe these characteristics make MTM more useful. MTM is a means of obtaining and recording information. How well you obtain it and what you do with it, will determine the value to you. In this way, you might say, it is like Time Study. Time Study is also a means of gathering information. The basic difference is that Time Study requires obtaining the time, while MTM requires obtaining the motion which has an accepted time value already established.

Now let us discuss our use of MTM in Methods and Standards:

1. The first step taken is to determine the pattern to be used, and here we make our first use of Methods. The question arises, is it possible to cut the garment from a one-piece pattern or must it be two or more parts?

(a) What effect on use of fabric?

(b) What effect on fabric lay-up time?

(c) What effect on pattern mark-out time?

(d) What effect does pattern design have on cutting and sewing operations?

(e) What is the ideal pattern and fabric to use?

2. The second step is to determine the proper process analysis for the construction of the garment. It is known that the actual sewing requires about 30% of an operator's time on most operations; therefore, we must ask ourselves these questions:

(a) What operations are necessary?

(1) Can we eliminate? Must this particular work be done at all? Is there a way to save the operation?

(2) Can we combine? Must the operation be performed separately? Here is the clue to the use of attachments to combine two or more operations into one.

(3) Can we rearrange the sequence? Why do the jobs in that particular order? Would it be easier to do other operations if arranged differently?

(4) Can we simplify? What can be done to ease the work involved on each operation? What if any attachments can be used to create more continuous machine use?

3. Our third step is to determine what type stitch and machines can be used for this particular garment construction. There are numerous sewing heads available and it doesn't make much difference which one is used if it is in good repair and efficient in operation; the only important question is—is it the best machine for the job?

4. The fourth step is the work layout or arrangement of the work place for each operation. It is important to develop rhythmical, free-swinging motions. Good operator performance is a seemingly effortless rhythm. To develop this smoothness, certain principles must be followed in the job method.

(a) Try to arrange the work so both hands complete their particular tasks at the same time. One example is the guid-

ing of one piece of work while the other hand prepares the next piece for sewing. The last stitch and the end of the positioning of the next piece should occur naturally at the same time.

(b) Arm motions should be opposite, and occur together and over similar paths. It is easy to build a rhythm with this type of work path. Hold elbows at the sides of the body and swing the forearms in opposite but similar paths at the same time and the natural swing of such motion may be noted.

(c) Motions should follow oval, rather than flat, paths. It is easier to make a somewhat circular or oval path than the flat, horizontal path.

(d) The work arrangement should require the simplest type of motions. It has been established that it is easier to use a finger motion than a wrist motion. By the same token, forearm, full arm and body motions call for increasingly greater effort in that order.

(e) Locate the parts in such manner to allow aside garments position to take you to general location of obtaining next part.

(f) Decide on permanent location for maintenance materials to develop smoother process. When operator knows where such items as scissors, screw driver and bobbins are, there is no lost motion.

(g) Provide the best possible work conditions, such as chair, table adjustment and material control. There is no easier or better way to set up the most efficient method than the use of MTM, which stresses method to obtain standards.

With the completion of the methods check-up, we are ready to start the detailed analysis of each operation to obtain the standards.

To make MTM analysis of an operation, it is first necessary to obtain the motions the operator uses to perform her work. It will be noted that the basic motions of most importance are:

Reach	Move	Release
Grasp	Position	

Next, we must determine the condition under which each motion is made. There are different conditions affecting each motion such as length of reach and the state of the object reached for. These conditions affect the time assigned to the motion; they must be determined before the time can be assigned from the table of values.

It is only necessary to observe enough complete cycles of the operation to determine the correct motion pattern. The values for each element are then assigned from the data card and the elements totalled, then the allowances for rest, fatigue and delay are added. The final figure in TMU would then be converted to Standard Minutes or Hours per unit to complete the analysis.

When sewing operations are carefully analyzed, you will find they consist of few simple elements frequently repeated in different combinations. After thorough study and assignment of values to these, it is no longer necessary to make individual studies of each new operation. It is only necessary to determine the elements required from these standard elements and add them together for the allowed time of the operation involved. When all the standard elements are charted, you will find the data can be applied very rapidly. However, you will probably continue to revise and develop the data after starting to use it.

Now let me briefly summarize our benefits from MTM:

1. We now have detailed descriptions of methods used on all operations analyzed.

2. We have eliminated many unnecessary motions in the operations.

3. We have established more consistent standards.

4. Better development of work layout.

5. We establish many standards in advance of production.

6. It is easier and faster to train operators.

7. It provides a basis for determining whether a methods change has occurred and permits the revision of standards for it.

8. It is helpful in determining the value of new equipment.

9. Guides product design for lower cost.

10. Develops machine attachments to simplify operations.

11. Trained supervision to spot poor work patterns.

Although we have experienced these benefits from the use of MTM, we feel that we have only a good start in its use.

MTM ELEMENT ANALYSIS

Date: 2-2-56

Article: Men's boxer shorts		Style: 4100	
Operation: Assemble fronts		Oper. No.: 1	
Material: Broadcloth	Size:	Sheet: OF	
Standard Element: A2a	Thread: 2 cones 70/3		
Equipment: Singer 400W1	R.P.M.: 4000	S.P.T.: 15	

Description Left Hand	Motion	T.M.U.	Motion	Description Right Hand
		129	R10C	Reach to part
Grasp part as moved		3.5	G1B	Grasp part
to position, to assist		5.6	G2	Regrasp part
positioning with other part	G1B	13.5	M10C	Move part to position with
				other part
Position to other part	P2SSD	25.3	P2SSD	Position to other part
Regrasp for control	G 2	5.6	G 2	Regrasp parts for control
		72.0		

Use for positioning one part to another part.

TABLE A

Code No.	Description of Element	a Accurate Positioning 2"	4"	6"	8"	10"	12"	14"	16"	18"	20"	22"	24"	n Normal Pos.
1	Pick up and place on table or lap			31	34	37	40	44	47	50	53	56	59	—
2	Pick up and Pos. 1 part to part on table or other hand			67	70	73	76	79	83	86	89	92	95	-10
3	Pick up and Pos. under foot (1 part)			74	77	80	83	86	88	91	94	98	101	-10
4	Pick up and Pos. together 2 parts (R & L)			77	80	83	86	89	92	95	98	102	105	-10
5	Pick up Pos. together 2 parts & underfoot (r & L)			120	123	126	129	132	136	139	142			-20
6	Move part under foot to new Pos.	38	43	47	50	53	56	59						—
7	Position part under foot	Accurate 50						Normal 40						
8	Position in single folder													16
9	Position in double folder													27
10	Position in lap seam folder													32

NOTES: Accurate positioning based on P2SSD
Normal Positioning based on P1SSD
Where materials tend to cohere or must be compressed in positioning, add 11 TMU's and indicate as AP2.

APPLICATION V

OPERATION ANALYSIS AND STANDARD

Date: 12-5-55

Operation:	Join right shoulders	Oper. No.:	1
Article:	Men's T-Shirt	Sheet:	1 of 1
Material:	Light weight 1x1 cotton	Style:	129-1
Analyst:	L. M. G.	Thread:	4-70/3, 4-30/1, 1-30/2

	Machine	S.P.I.	R.P.M.	Needles	Attachments
Used:	W & G Flatlock	12	2800	4	
Proposed:					

No	Description of Element	TMU's	No.	Description of Element	tmu's
1.	Pick up back shoulder (right hand)	31		Sub. Total	286
	Place on machine arm				
	A 1-6"		8.	Pick up to clip apart	10
				H1	
2.	Pick up front shoulder (left hand)	60			
	position to back shoulder on		9.	Clip chain and drop garment	25
	machine arm			G1 RL2	
	A2m-8"				
			10.	Bundle and clerical	34
3.	Position parts under foot	40			
	A7m			I1-4-14 J1-2-3	
4.	Prestitch	17		810 + 24 = 34	
	2 FM				
5.	Align for sew	20			
				Total	355
6.	Sew entire shoulder	78			
	Sew 7"				
7.	Stack aside 2nd shoulder	40			
	H3				
		286			

Sketch or Remarks

Bundle not untied for this operation. Garments laid under machine arm with backs to right and shoulders facing operator.

Total Net Hrs. Per Piece	.00355
S.A.H. per (doz) @ (25)% Allow.	.0568
Production Per (8) Hours	141.0
Cost Per (doz) @ ($1.25) per hr.	.0710
Dozens per bundle	2
Rate per bundle	.1420

OPERATION LIST

ARTICLE: T-Shirts DATE: 6-12-56

PRODUCTION: 3000 Dozen's Per Week

Oper. No.	Description of Operation	S.A.H. Per Doz.	Doz. Per 8 Hrs.	Type of Machine	No. of Mach's Req'd.	No. of Oper's Req'd.
1.	Join Right shoulder	.0568	141	Flatlock	4.25	
2.	Tube sleeve ends	.0560	142	U. S.	4.23	
				52800		
3.	Tube neck opening	.0633	126	U. S.	4.76	
				52800		
4.	Close left shoulder	.0582	137	Flatlock	4.38	
5.	Tape neck and shoulder	.0685	116	U. S.	5.17	
				1200N2		
6.	Close and set sleeves	.2062	39	W&C	15.4	
				Super-Lock		
7.	Attach label	.0662	121	Singer69	4.96	
8.	Hem bottom	.0854	94	Singer	6.39	
				246-14		
9.	Hem bottom	.1198	67	Metropol-	8.95	
				itan		
10.	Tack neck	.0333	240	Singer	2.50	
				69-26		
11.	Trim and inspect	.1167	68	-	-	
12.	Fold for press (with heat seal)	.0959	83	-	-	
	"Note" Method change on hem operation.					
	40% increase in production and 8%					
	increase in operators average hourly					
	earnings.					

APPLICATION VI

MTM STANDARDS USED IN HEAVY INDUSTRY

By

Paul Broadstone
Clark Equipment Company

"In the days of silent pictures, five-cent cigars, and hand-wound phonographs it cost about 30 cents to move a cubic yard of dirt. Now in the electronic age of hi-fi, guided missiles, and a general price index that has risen 265%, it still costs only 30 cents to move a yard of dirt. Why? The answer is modern equipment—machines that feature high capacity, speed and handling ease." Those were also the days when the man, the mule, and the slip scraper could be hired for $10 a day.

A little later when Kate Smith had just begun to sing "When The Moon Comes Over The Mountain," a tractor drawing a scraper at three miles per hour replaced the man and the mule, and still, dirt could be moved for 30 cents a yard. This type of moving and this cost of 30 cents a yard can be accomplished only because of heavy equipment—the type of heavy equipment that we are going to discuss today. This equipment is manufactured to effectively utilize manpower and tax dollars on the construction job.

As manufacturers we must keep in pace with this philosophy. We at CMD believe that we have kept pace because as our sales increased from three million in 1953 to forty-six million in 1958, our direct labor cost to sales dollar has diminished and our indirect cost has decreased. Basing our average wages per hour in 1956, we have raised these wages 112%. This was done despite the fact that in late 1957 and early 1958 we had introduced seven new models and products into our line.

Of course, we use an Incentive; and, of course, we use Standard Data; and, we are developing more Data every day. We are using MTM as a basis for our basic Standard Data where it can be made applicable.

We believe that the MTM technique is more of a science than a philosophy, and we believe as H. S. Keyes, Jr., who in his book, How to Develop Your Thinking Ability, wrote, "The scientific way to tell whether a cake tastes good is to eat it. The philosophical way is to analyze the recipe and psychoanalyze the cook." We are not philosophers but we do feel that in a minor way we are scientists. Consequently, we have cut ourselves a large portion of the MTM cake and have found it to our liking.

Our manufacturing consists entirely of heavy metal, processing, welding and assembly. Following the text of this presentation, you will find one of the several basic analyses that we have made in our shop.

As we began our MTM work we did not dive into shallow water. Rather, we made some comparative checks of MTM Basic Standards vs. Time Studies and other basic values. Our results showed comparative accuracy to be within acceptable percentage. And, as a result, we have placed our basic standards, using MTM, into use. Another result of using MTM is a decrease in the number of union grievances regarding standards, although no sales program was put on in an effort to sell our union committee on this technique. Our experience has shown us that the basic difference between using MTM Standards in long-cycle heavy industry and highly repetitive light work might be listed thusly:

1. Operation crews frequently involve more than one person.
2. More operations are processed controlled.
3. Variables frequently are limited so that it is expeditious to use averages rather than carry variables.
4. Less accuracy may occur but also we may condone less accuracy.
5. More body motions are employed.
6. There are fewer simultaneous motions.

To minimize the conditions as much as possible so that variables may be limited or controlled we establish procedures and methods as accurately as possible, after which we make a very thorough analysis of the motion patterns. Only at this point do we condone averages. In addition to using MTM for our shop values, they are also being used in office procedure analyses of indirect operations.

Our conclusion, needless to say, is the same as other MTM practitioners. That is, that we think it worthwhile to use MTM in heavy shop operations.

STANDARD PRACTICE

CLARK EQUIPMENT COMPANY
Construction Machinery Division
PIPESTONE PLANT

File Word STANDARD DATA
Procedure No. 486-0108 Rev. No.
Sheet No. 1 of 6

SUBJECT DO-ALL SAW AND LANCO DRILLMATION STANDARD DATA

DEPARTMENT 402 - MACHINE SHOP

COMPILED BY	REVISED BY	APPROVED BY	DATE	DISTRIBUTION
E. Pollard D. Woodford		P. Broadstone		I.E. Standard Practice Manuals

1. EQUIPMENT

   Do-all power saw IBM no. 7001

   Lanco drillmation IBM no. 1600

   Air operated hand grinder

11. PRODUCT

   Any processed cylinder tube assigned to these machines

111. OPERATION

   Do-all power saw - saw to length

   Lanco drillmation - drill one or two holes in cylinder tube 1/2" to 1" diameter.

   Hand grinder - burr saw and drilled hole burr.

1V. SAFETY DEVICES

   As approved by the Safety Department

V. INSPECTION

   A. Check first piece - operator and inspector

   B. Spot check during run - operator

   C. Check before issuing move ticket -

CMD-224 (8P)

inspector

V1. MATERIAL HANDLING

A. Small pieces by hand (0 - 50 lbs.)

B. Large pieces by hoist (over 50 lbs.)

C. Material moved to area and parts from area by material handlers and fork truck operators.

V11. ADDITIONAL INFORMATION

A. HISTORY

This standard data was compiled from actual studies taken at the Pipestone Plant in Department 403 and from MTM Data. Modifications may be necessary where unusual conditions exist. In these cases actual studies will be taken and used until sufficient information is compiled to enable the Standards Department to determine standard data. All rates established by standard data are subject to actual check studies, if and when the foreman and the operator, with logical reasons, request a check study.

B. Code numbers have been assigned to the standard elemental values so that any standard value used may be traced to the source of the standard. These standards are sub-

ject to change only when the actual work changes, and in such cases it is the responsibility of the foreman to notify the Standards Department.

V111. APPLICATION

A. The procedure will be established by a time-study analyst observing the job, from which the standard "saw, drill and burr" will be established by using form no. IE-0108 and applying the "master" elemental descriptions and values to it.

B. Standard work sheet form IE-0108 for do-all saw and lanco drillmation will be used in working up standards.

C. The "do-all saw, lanco drillmation," values are set at base time. Add allowances as follows:

15% - Saw, Drill and Burr
13% - Saw and Burr

D. The saw time value is limited by the necessary time required to drill and burr piece on drill. Only the saw time value should be considered on the work sheet. A tool allowance for drilling should be added using formula:

$$(.045 + .005 \times \text{no. drills} \times 1.42)$$

The drill and burr time is limited out by the saw time value. Following is a list of the drill and burr elements, which are effective

as soon as the saw blade contacts the stock to start a cut.

Get piece saw table to drill table (hand), or hoist piece saw table to drill table and aside hoist locate piece to stops.

Engage panel for secure piece and up drill or drills.

Drill piece (auto).

Out drill or drills and release piece (auto).

Aside piece to pallet (hand) or hoist piece to pallet.

Burr (2) sawed ends and break thru side of hole or holes with hand grinder.

When piece is sawed and not drilled, the burr time is limited out by burring the sawed edges of asided piece with hand grinder during the saw time cycle.

IX. ELEMENTAL DESCRIPTIONS AND VALUES

CODE NO.	ELEMENTAL DESCRIPTIONS	VALUES
002-044	Get hoist to stock - MTM Data	.168/cycle
002-045	Position lift chain on hoist - MTM Data	.104/cycle
002-046	Hook stock one end - MTM Data	.160/cycle
002-047	Hook stock opposite end - MTM Data	.228/cycle
002-048	Hoist stock to conveyor - clock	.50+.0006/lb.
002-049	Unhook stock one end - MTM Data	.146/cycle

002-050	Unhook stock opposite end - MTM Data	.153/cycle
002-051	Position stock thru vises to stop - clock	.10+.0002/lb.
002-052	Secure vises, engage saw control, to prepare to cut first piece - MTM Data	.196/cycle
026-001	Saw piece (cylinder tube) - clock Compute square inches of cross section of cylinder tube by using formula: (I.D. + WALL) x 3.1416 x WALL	1.+.2892/sq.in.
026-002	Up saw after end of cut (auto) - clock Set by adjustment to have necessary clearance to permit stock to index.	.07/occ.
026-003	Index stock per specification (auto) - clock This value is to be used for each index required to move stock for the specified length per piece.	.075+.0076/in.
026-004	Return vise (auto) succeeding first index and start second index. Double time for use with triple index. For single index do not use - clock	.25/occ.
026-005	Down saw and start (auto). This element begins at end of auto. Index and time value can be set by adjustment - clock	.05/occ.

STANDARD PRACTICE

File Word STANDARD DATA

Procedure No. 486-0108 Rev. No.

Sheet No. 6 of 6

026-006	Up saw and stop (manual) clock	.119/occ.
026-007	Release vises (manual) - MTM Data	.063/occ.
002-053	Measure and set remnant stock to saw last piece - clock	.50+.0065/in.
002-054	Secure vises and engage saw to saw last piece from stock per cycle MTM Data	.098/cycle
014-006	Aside scrap (hand) radial drill	.0653+.0027/lb.
014-005	Aside scrap (hoist) radial drill	.87+.0017/lb.
014-025	Remove last piece from vises - MTM Data Constant 58.9 TMU + M_B# x .0006 = MINUTES	
014-005	Position, hook and hoist last piece aside - radial drill	.87+.0017/lb.

SAW, DRILL AND BURR CYLINDER TUBE - STANDARD DATA
WORK SHEET IE-0108

Part Name
Size of Piece
Size of Stock
Saw Speed and Feed
Computed by

Part No.
Oper. No.
Mach. No.
Dept. No.
Date

CODE NO.	ELEMENTAL DESCRIPTION	VALUE	OCC.	MINS.
002-044	Get hoist to stock	.168/cycle		
002-045	Pos. lift chain on hoist	.104/cycle		
002-046 & 002-047	Hook stock (two ends)	.388/cycle		
002-048	Hoist stock to conveyor	.50+.0006/lb.		
002-049 & 002-050	Unhook stock (two ends)	.299/cycle		
002-051	Pos. stock thru vises to stop	.10+.0002/lb.		
002-052	Secure vises, engage saw (first piece)	.196/cycle		
026-001	Saw piece	1.+.2892/sq. in.		
026-002	Up saw (auto)	.07/occ.		
026-003	Index per index cycle	.075+.0076/in.		
026-004	Return vise (succeeding index)	.25/occ.		
026-005	Down saw and start (auto)	.05/occ.		
026-006	Up saw and stop (manual)	.119/occ.		
026-007	Release vises (manual)	.063/cycle		
002-053	Measure and set stock for last piece	.5+.0065/in.		
002-054	Secure vises and engage saw (last piece)	.098/cycle		
014-006	Aside scrap (hand)	.0653+.0027/lb.		
014-005	Aside scrap (hoist)	.87+.0017/lb.		
014-025	Remove last pc. from vises (hand)			
014-005	Pos., hook and hoist last piece aside	.87+.0017/lb.		

Total Base Time ---------------
Base Time Per Piece------------
Allowance %-----------------
Tool Allowance ----------------
Standard Time Per Piece -------
Target -----------------------
Task -------------------------
Premium Unit------------------
Class Money
Premium ----------------------
Standard Hours----------------

APPLICATION VI

MTM ELEMENT ANALYSIS

File

Part Name DoAll Saw and Lanco Drillmation Part No.
Oper. Name Oper. No.
Operator No. Analyst E.P. Date 10-29-58

DESCRIPTION - LEFT HAND	F	MOTION	TMU	MOTION	F	DESCRIPTION - RIGHT HAND
Get hoist to stock (002-044)						
Reach switch box			21.5	R24B		Reach hoist chain
Grasp			2.0	G1A		Grasp
Apply pressure			16.2	AP1		Apply pressure
			55.8	TBC1	3	Turn body 90°
Move hoist			170.0	W10PO		Move hoist
Release			2.0	RL1		Release
Next motion			13.0	R14E		Next motion
			280.5	x .0006	=	.168
Pos lift chain on hoist - (002-045)						
			29.0	B		Bend body fwd.
Reach chain ring		R24B	21.5			
Grasp		G1A	2.0			
			31.9	AB		Arise from Bend
Move chain ring to hook		M36A25	34.6			Reach hoist chain hook
Move chain ring to hook		M6C25	22.3			Grasp
POS ring on hook		PINSE	10.4			
Release ring		RL1	2.0			Release
Next motion		R24E	19.2			Next motion
			172.9	x .0006	=	.104
Hook one end of stock - (002-046)						
			29.0	B		Bend body fwd.
			21.5	R24B		Reach hook
			2.0	G1A		Grasp
			26.8	M24B10		Move hook
			31.9	AB		Arise
			85.0	W5PO		Move hook to cyl. end
			18.6	TBC1		Turn body 90°
			20.8	M12C10		Move hook to cyl.
			10.4	PINSE		POS hook
			2.0	RL1		Release
			19.2	R24E		Next motion
			267.2	x .0006	=	.160
Hook stock opp. end - (002-047)						
Turn body 90°		TBC1	18.6			
Walk 5 paces		W5P	75.0			
Bend copy		B	29.0			
Reach hook		R24B	21.5			
Grasp		G1A	2.0			
Move hook		M24B10	26.8			
Arise		AB	31.9			
Move hook to cyl. end		W5PO	85.0			
Turn body 90°		TBC1	18.6			
Move hook to cyl. end		M12C10	20.8			
Pos hook		PINSE	10.4			
Release		RL1	2.0			
Next motion		R24E	19.2			
Turn body 90°		TBC1	18.6			
			379.4	x .0006	=	.228

Sheet 1 Of

MTM ELEMENT ANALYSIS

File

Part Name DoAll Saw & Lanco Drillmation Std Data Part No.
Oper. Name Oper. No.
Operator No. Analyst E.P. Date 10-29-58

DESCRIPTION - LEFT HAND	F	MOTION	TMU	MOTION	F	DESCRIPTION - RIGHT HAND
Unhook one end of stock -- (002-049)						
Turn body 90°		TBC1	18.6			
Walk 8 paces		W8P	120.0			
Turn body 90°		TBC1	18.6			
Reach hook		R12B	12.9			
Grasp		G1A	2.0			
Disengage		D1E	4.0			
Move hook to aside		M24B10	26.8			
Release		RL1	2.0			
Next motion		R24E	19.2			
Turn body 90°		TBC1	18.6			
			242.7	X.0006	=	.146
Unhook opp end of stock -- (002-050)						
		150.0	150.0	W10P		Walk (10) paces
			18.6	TBC1		Turn body
			12.9	R12B		Reach hook
			2.0	G1A		Grasp
			4.0	D1E		Disengage
			26.8	M24B10		Move hook to aside
			2.0	RL1		Release
			10.2	R24E		Next motion
			18.6	TBC1		Turn body
			254.1	X.0006	=	.153
To saw controls & engage - (002-052)						
			18.6	TBC1		Turn body 90°
			30.0	W2P		Walk (2) paces
			18.6	TBC1		Turn body 90°
			180.0	W12P		Walk (12) paces
			18.6	TBC1		Turn body 90°
			17.5	R30A		Reach saw control
			2.0	G1A		Grasp
			10.6	AP2		Apply pressure
			3.4	T90°S		Turn 90°
			2.0	RL1		Release
			22.9	R30E		Next move
			326.2	X.0006	=	.196

Sheet 2 Of

MTM ELEMENT ANALYSIS

File

Part Name DoAll Saw & Lanco Drillmation Std Data Part No.
Oper. Name Oper. No.
Operator No. Analyst EP Date 10-29-58

DESCRIPTION - LEFT HAND	F	MOTION	TMU	MOTION	F	DESCRIPTION - RIGHT HAND
Release vises - (026-007)						
Turn body 90°		TBC1	18.6			
Bend		B	29.0			
Reach lever		R24A	14.9			
Grasp		G1A	2.0			
Apply pressure		AP 2	10.6			
Turn lever		T180S	9.4			
Release		RL 1	2.0			
Next motion		R24E	19.2			
			105.7	.0006	=	.063
Secure vises & engage saw after meas & set for last pc - (002-053)						
			18.6	TBC1		Turn body 90°
			29.0	B		Bend body
Reach lever		R24A	14.9			
Grasp		G1A	2.0			
Apply pressure		AP2	10.6			
Turn lever		T180S	9.4			
Release		RL1	2.0			
Next motion		R24E	19.2			
			18.6	TBC1		Turn body 90°
			14.9	R24A		Reach control
			2.0	G1A		Grasp
			10.6	AP2		Apply pressure
			9.4	T180S		Turn lever
			2.0	RL1		Release
			163.2	X.0006	=	.098
RMV last PC from vises to table -- (014-025)						
			21.5	R24B		Reach PC
			2.0	G1A		Grasp
				M_B#		Move PC from vises(slide)
~~Reach PC~~		R10B	12.2			
~~Grasp PC~~		G1A	2.0			
~~Move PC~~				M_B#		Move PC
~~Release~~			2.0	RL1		Release
~~Next motion~~			19.2	R24E		Next motion
		Constant→	58.9	X.0006	=	.035
				Variable	=	M_B#

Sheet 3 Of

MTM ELEMENT ANALYSIS SUMMARY

File

Part Name DoAll Saw and Lanco Drillmation Std. Data Part No.
Oper. Name Oper. No.
Machine Mach. No.
Department 405 Analyst E.P. Date 10-29-58 Approved Date
Material Cylinder Tubing

Tools

Material Handling

Quality

Safety

Remarks

Code No.	ELEMENT DESCRIPTION	Time TMU	Occurrence Per Cycle	Total Per Cycle
002-044	Get hoist to stock	280.5		.168
002-045	Position lift chain on hoist	172.9		.104
002-046	Hook stock one end	267.2		.160
002-047	Hook stock opp. end	379.4		.228
002-048	Hoist stock to convyeor (clock).50 + .0006/lb.			
002-049	Unhook stock one end	242.7		.146
002-050	Unhook stock opp. end	254.1		.153
002-051	Pos stock through vises to stop (clock) .10 + .0002/lb.			
002-052	Secure vises, engage saw control - 1st pc.	362.2		.196
026-001	Saw Pc. (clock) 1. + .2892/sq. in.			
026-002	Up saw after end of cut - auto (clock)			.070
026-003	Index stock - auto (clock) .075 + .0076/in.			
026-004	Return vise - auto (clock)			.250
026-005	Down saw and start - auto (clock)			.020
026-006	Up saw and stop - manual (clock)			.119
026-007	Release vises - manual	105.7		.063
002-053	Measure and set rem. stock - last pc. (clock) .50 + .0065/in.			
002-054	Secure vises and engage saw - last pc.	163.2		.098
014-006	Aside scrap-hand (radial drill).0653 +.0027/lb.			
014-005	Aside scrap-hoist (radial drill).87 + .0017/lb.			
014-025	Remove last pc. from vises	58.9 + M_B		
014-005	Hoist last pc. aside (radial drill) .87 + .0017/lb.			

Total TMU Per Cycle
Allowances %
Allowed Hours Per
Pieces Per Hour

Sheet Of

APPLICATION VII

USE OF MOTION COMBINATIONS FOR DEVELOPING STANDARD DATA

By

William E. Ross
Tractomotive Corporation

It is a pleasure to present our thinking and experience to you, but being here to discuss this subject with you is no presumption on our part that the problems of motion combinations have been solved and that consequently detailed motion analyses can be dispensed with. Rather it is our hope that whatever is said might help to crystallize our thinking and efforts in this field to our mutual advantage.

Tractomotive Corporation is currently using MTM to develop manual standard data for use in its machining and welding operations. The usual approach to building standard data is being used:

1. Floor observations of working conditions.

2. Visualization of standardized method and the various elements of work.

3. Analyzing individual elements of work (called element analyses).

4. Determining constants and variables.

5. Resolving constants and variables into standard data elements (referred to as element summaries).

Since various operating costs were being scrutinized for possible reductions, we asked ourselves the question: How can standard data development costs be reduced and at the same time accelerate data output? We have answered or are answering this question in the following ways.

EXTENDED BASIC ELEMENTS

First, calculations are now being minimized through the use of what we call, "extended basic elements" (EBE).

Examples:
- A. Eye Travel
- B. Moves with weight (see Exhibit A)
- C. Cranking (_C_) (see Exhibit B)
- D. Cranking (M_B)
- E. Walking

This resulted in (1) minimizing errors in calculating time values for basic elements, and (2) savings in time:

60% for moves with weight.
13% for _C_ type cranking.
75% for M_B type cranking.

Calculations, however, represent but a small part of the standard data process and from a savings standpoint are a "drop in the bucket." Something more substantial is needed to effect cost reduction.

VARIABLE MOTION COMBINATIONS

Second, we are now beginning to reduce the duplication of simple elements through the use of "variable motion combination" charts.

Some motion patterns have a high frequency of occurrence in standard data elements; reach-grasp-move is a typical example. Very often this type of pattern requires a separate element analysis because of minor differences in characteristics from previous analyses; i.e., distance reach or moved, weight moved, and type of reach, move, and/or grasp. This was initially resolved into reach-grasp-move with weight charts (see Exhibit C, two sheets).

The reaches and moves vary by distance and by types "B" and "C." Grasp and weight moved are constants and consequently require separate sheets to vary. Deviations in time from the original data are less than 1%. The results are: (1) simple elements can be described on a summary sheet without separate element analyses, and (2) development time for these elements is consequently reduced almost in half.

The next step resulted in a single reach-grasp-move-release multi-variable chart (see Exhibit D). Deviations from actual are within + or - 3%. Results: similar to the previous charts

but less bulk in paper. (A lessening in time saved from the other charts tends to indicate that this approach is too detailed and complicated for maximum effectiveness and should be simplified.)

With these developments covering a significant proportion of the work elements being analyzed, we feel we are taking a major step in the direction of cost reduction.

STANDARD MOTION PATTERNS

Third, along with the development of "variable motion combinations" it was realized that there are many specialized patterns of work which are repetitive throughout our operations. If these could be analyzed once and be properly cataloged for reference, no further analysis would be required except to fit them into the over-all methods of work where they occur. We call them "standard motion patterns" (SMP).

Typical areas are:

A. Checking
(1) Micrometers, (2) Scales, (3) Calipers, (4) plug gages, etc.

B. Secure and loosen
(1) Strap clamp assemblies, (2) hand and wrench turning, (3) hand and wrench tightening and loosening, (4) jig and fixture components (bushings, toggle clamps, cam locks, etc.)

C. Piece handling
(1) jumbled parts, (2) stacked parts, (3) upright cylinders, (4) hoist handling

D. Et al.

As an example, we would like to review with you a motion pattern which we have standardized: Hand turn (see Exhibits E & F). There are two aspects to the standardized pattern:

1. The element analysis is composed of an element description, limitations to the method, detailed methods analysis, and a reference to preceding and succeeding elements.

2. The element summary which resolves all of the considerations into an integrated presentation of resistance - spin, normal, and heavy, size of object, revolutions, reference code, and development.

As a result:

1. Substantial amounts of time are saved by reducing the need to separately analyze specialized patterns which recur in different areas of work, i.e., lathes, drills, welding, assembly, etc.

2. The consistency of data application is improved.

SIMPLIFICATION OF STANDARD DATA DEVELOPMENT

We now come to the point where the results of using the variable motion combinations and the standard motion patterns become dramatically apparent. Instead of "fabricating" standard data elements from basic MTM data in a series of detailed analyses, many elements can simply be "assembled" very quickly. As an example, refer to Exhibit G, "Assemble and Tighten Nut to Secure Plates." (Element analyses would be developed as necessary in lieu of any existing or applicable combinations or patterns and would be referenced into the element summary sheet.) Result: Standard data elements which would perhaps require one or more hours to develop with detailed analyses can be resolved in a matter of 15 to 30 minutes on an element summary sheet.

We at Tractomotive have only touched upon a major field of exploitation and the results and benefits are becoming more and more apparent to us. We know that the costs for developing MTM standard data can be reduced somewhat by extending the basic MTM data to minimize calculations, and substantially by the use of variable motion combinations and standard motion patterns. However, this is only a beginning but we feel it is in the right direction.

In my experience, every standard data program has had to start from "scratch," with basic MTM data, and ended up with more or less what has been outlined herein. Then too, most of this material has ended up in each company's files to be kept, in effect, like the ancient guild secrets. Perhaps your own experience parallels this.

Standardization and work simplification which have been successfully applied in other fields to achieve cost reduction and universal usage should be equally applicable in the field of work measurement. It is our hope that steps will be taken soon which can facilitate the interchange of information which can lead to work measurement standardization of a universal nature.

APPLICATION VII

Exhibit A

M_B MOVE WITH WEIGHT ALLOWANCES (IN TMU)

Weight in Pounds

INCHES	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5
1	2.0	4.3	6.1	7.9	9.8	11.7	13.5	15.3	17.2	19.0
1	2.9	5.3	7.1	9.0	10.9	12.8	14.7	16.5	18.5	20.4
2	4.6	7.1	9.0	11.0	13.0	15.0	16.9	18.9	20.9	22.9
3	5.7	8.2	10.2	12.3	14.4	16.4	18.4	20.4	22.5	24.6
4	6.9	9.5	11.6	13.7	15.8	17.9	20.0	22.1	24.2	26.4
5	8.0	10.7	12.8	15.0	17.2	19.3	21.4	23.6	25.8	28.0
6	8.9	11.6	13.8	16.0	18.3	20.5	22.6	24.9	27.1	29.4
7	9.7	12.5	14.7	17.0	19.2	21.5	23.7	26.0	28.3	30.6
8	10.6	13.4	15.7	18.0	20.3	22.7	24.9	27.2	29.6	31.9
9	11.5	14.4	16.7	19.1	21.4	23.8	26.1	28.5	30.9	33.3
10	12.2	15.1	17.4	19.9	22.3	24.7	27.0	29.5	31.9	34.6
12	13.4	16.4	18.8	21.3	23.8	26.3	28.6	31.1	33.6	36.1
14	14.6	17.7	20.1	22.7	25.2	27.8	30.2	32.8	35.3	37.9
16	15.8	19.0	21.4	24.1	26.7	29.3	31.8	34.5	37.1	39.7
18	17.0	20.2	22.8	25.5	28.1	30.9	33.4	36.1	38.8	41.5
20	18.2	21.5	24.1	26.9	29.6	32.4	35.0	37.8	40.5	43.3
22	19.4	22.8	25.4	28.3	31.1	33.9	36.6	39.5	42.2	45.1
24	20.6	24.0	26.8	29.7	32.5	35.5	38.2	41.1	44.0	46.9
26	21.8	25.3	28.1	31.1	34.0	37.0	39.8	42.8	45.7	48.7
28	23.1	26.7	29.5	32.6	35.6	38.7	41.5	44.6	47.6	50.7
30	24.3	28.0	30.9	34.0	37.1	40.2	43.1	46.3	49.3	52.5

Exhibit B

CRANKING (C) IN TMU
DIAMETER IN INCHES

REVOLUTIONS	2"	3"	4"	5"	6"	7"	8"	9"	10"	12"	14"	16"	18"
CONTINUOUS CRANKING													
1	14.9	15.8	16.6	17.3	17.9	18.4	18.8	19.2	19.6	20.2	20.7	21.2	21.6
2	24.6	26.4	28.0	29.4	30.6	31.6	32.4	33.2	34.0	35.2	36.2	37.2	38.0
3	34.3	37.0	39.4	41.5	43.3	44.8	46.0	47.2	48.4	50.2	51.7	53.2	54.4
4	44.0	47.6	50.8	53.6	56.0	58.0	59.6	61.2	62.8	65.2	67.2	69.2	70.8
5	53.7	58.2	62.2	65.7	68.7	71.2	73.2	75.2	77.2	80.2	82.7	85.2	87.2
6	63.4	68.8	73.6	77.8	81.4	84.4	86.8	89.2	91.6	95.2	98.2	101.2	103.6
7	73.1	79.4	85.0	89.9	94.1	97.6	100.4	103.2	106.0	110.2	113.7	117.2	120.0
8	82.8	90.0	96.4	102.0	106.8	110.8	114.0	117.2	120.4	125.2	129.2	133.2	136.4
9	92.5	100.6	107.8	114.1	119.5	124.0	127.6	131.2	134.8	140.2	144.7	149.2	152.8
10	102.2	111.2	119.2	126.2	132.2	137.2	141.2	145.2	149.2	155.2	160.2	165.2	169.2
EACH 1	9.7	10.6	11.4	12.1	12.7	13.2	13.6	14.0	14.4	15.0	15.5	16.0	16.4
ADD'L. 10	97.0	106.0	114.0	121.0	127.0	132.0	136.0	140.0	144.0	150.0	155.0	160.0	164.0
20	194.0	212.0	228.0	242.0	254.0	264.0	272.0	280.0	288.0	300.0	310.0	320.0	328.0
30	291.0	318.0	342.0	363.0	371.0	396.0	408.0	420.0	432.0	450.0	465.0	480.0	492.0
40	388.0	424.0	456.0	484.0	508.0	528.0	544.0	560.0	576.0	600.0	620.0	640.0	656.0
50	485.0	530.0	570.0	605.0	635.0	660.0	680.0	700.0	720.0	750.0	775.0	800.0	820.0
INTERMITTENT CRANKING													
1	14.9	15.8	16.6	17.3	17.9	18.4	18.8	19.2	19.6	20.2	20.7	21.2	21.6
2	29.8	31.6	33.2	34.6	35.8	36.8	37.6	38.4	39.2	40.4	41.4	42.4	43.2
3	44.7	47.4	49.8	51.9	53.7	55.2	56.4	57.6	58.8	60.6	62.1	63.6	64.8
4	59.6	63.2	66.4	69.2	71.6	73.6	75.2	76.8	78.4	80.8	82.8	84.8	86.4
5	74.5	79.0	83.0	86.5	89.5	92.0	94.0	96.0	98.0	101.0	103.5	106.0	108.0
6	89.4	94.8	99.6	103.8	107.4	110.4	112.8	115.2	117.6	121.2	124.2	127.2	129.6
7	104.3	110.6	116.2	121.1	125.3	128.8	131.6	134.4	137.2	141.4	144.9	148.4	151.2
8	119.2	126.4	132.8	138.4	143.2	147.2	150.4	153.6	156.8	161.6	165.6	169.6	172.8
9	134.1	142.2	149.4	155.7	161.1	165.6	169.2	172.8	176.4	181.8	186.3	190.8	194.4
10	149.0	158.0	166.0	173.0	179.0	184.0	188.0	192.0	196.0	202.0	207.0	212.0	216.0

APPLY WEIGHT FACTORS

REACH - MOVE WITH GIA UP TO 47.5#

	4 RB	4 RC	6 RB	6RC 8RB	8RC 10RB	10RC 12RB	12RC 14RB	14RC 16RB	16RC 18RB	18RC 20RB	20RC 22RB	22RC 24RB	24RC 26RB	26RC 28RB	28RC 30RB	30 RC
4 MB	34.8	36.8	37.0	38.5	39.9	41.3	42.7	44.1	45.5	46.9	48.4	49.8	51.1	52.6	54.0	55.1
4 MC	36.4	38.4	38.6	40.1	41.5	42.9	44.3	45.7	47.1	48.5	50.0	51.4	52.7	54.2	55.6	56.7
6 MB	37.8	39.8	40.0	41.5	42.9	44.3	45.7	47.1	48.5	49.9	51.4	52.8	54.1	55.6	57.0	58.1
6 MC	39.9	41.9	42.1	43.6	44.0	46.4	47.8	49.2	50.6	52.0	53.5	54.9	56.2	56.7	59.1	60.2
8 MB	40.3	42.3	42.5	44.0	45.4	46.8	48.2	49.6	51.0	52.4	53.9	55.3	56.6	58.1	59.5	60.6
8 MC	42.1	44.1	45.3	45.8	47.2	48.6	50.0	51.4	52.8	54.2	55.7	57.1	58.4	59.9	61.3	62.4
10 MB	43.0	45.0	46.2	46.7	48.1	49.5	50.9	52.3	53.7	55.1	56.6	58.0	59.3	60.8	62.2	63.3
10 MC	44.7	46.7	47.9	48.4	49.8	51.2	52.6	54.0	55.4	56.8	58.3	59.7	61.0	62.5	63.9	65.0
12 MB	44.5	46.5	47.7	48.2	49.6	51.0	52.4	53.8	55.2	56.6	58.1	59.5	60.8	62.3	63.7	64.8
12 MC	47.2	49.2	49.4	50.9	52.3	54.7	55.1	56.5	57.9	59.3	60.8	62.2	63.5	65.0	66.4	67.5
14 MB	46.3	48.3	48.5	49.6	51.4	52.8	54.2	55.6	57.0	58.4	59.9	61.3	62.6	64.1	65.5	66.6
14 MC	49.8	51.8	52.0	53.5	54.9	56.3	57.7	59.1	60.5	61.9	63.4	64.8	66.1	67.6	69.0	70.1
16 MB	48.1	50.1	50.3	51.8	53.2	54.6	55.8	57.4	58.8	60.2	61.7	63.1	64.4	65.9	67.3	68.4
16 MC	52.5	54.5	54.7	56.2	57.6	59.0	60.4	61.8	63.2	64.6	66.1	67.5	68.8	70.3	71.7	72.8
18 MB	49.9	51.9	52.1	53.6	55.0	56.4	57.8	59.2	60.6	62.0	63.5	64.9	66.2	67.7	69.1	70.2
18 MC	55.0	57.0	57.2	59.7	60.1	61.5	62.9	64.3	65.7	67.1	68.6	70.0	71.3	72.8	74.2	75.0
20 MB	51.7	53.7	53.9	55.5	56.8	58.2	59.6	61.0	62.4	63.8	65.3	66.7	68.0	69.5	70.9	72.0
20 MC	57.6	60.6	60.8	61.3	62.7	64.1	65.5	66.9	68.3	69.7	71.2	72.6	73.9	75.4	76.8	77.0
22 MB	53.5	55.5	55.7	57.2	58.9	60.0	61.4	62.8	66.0	67.4	68.9	70.3	71.6	73.1	74.5	75.6
22 MC	60.1	64.7	64.9	66.4	67.8	69.2	70.6	72.0	73.4	74.8	76.3	77.7	79.0	80.5	81.9	83.0
24 MB	55.3	57.3	57.5	60.0	60.4	61.8	63.2	64.6	66.0	67.4	68.9	70.3	71.6	73.1	74.5	75.6
24 MC	62.7	64.7	64.9	66.4	67.8	69.2	70.6	72.0	73.4	74.8	76.3	77.7	79.0	80.5	81.9	83.0
26 MB	57.1	59.1	59.3	60.8	62.2	63.6	65.0	66.4	67.8	69.2	70.7	72.1	73.4	74.9	76.3	77.4
26 MC	65.4	67.4	67.6	69.1	70.5	71.9	73.3	74.7	76.1	77.5	79.0	80.4	81.7	83.2	84.6	85.7
28 MB	59.1	61.1	61.3	62.8	64.2	65.6	67.0	68.4	69.8	71.2	72.7	74.1	75.4	76.9	78.3	79.4
28 MC	67.9	69.9	70.1	71.6	73.0	74.4	75.8	77.2	78.6	80.0	81.5	82.9	84.2	85.7	87.1	88.2
30 MB	60.9	62.9	63.1	64.6	66.0	67.4	68.8	70.2	71.6	73.0	74.5	75.9	77.2	78.7	80.1	81.2
30 MC	70.5	72.5	72.7	74.2	75.6	77.0	78.4	79.8	81.2	82.6	84.1	85.5	86.8	88.3	89.7	90.8

REACH - MOVE WITH A GIA UP TO 2.5#

	4 RB	4 RC	6 RB	6RC 8RB	8RC 10RB	10RC 12RB	12RC 14RB	14RC 16RB	16RC 18RB	18RC 20RB	20RC 22RB	22RC 24RB	24RC 26RB	26RC 28RB	28RC 30RB	30 RC
4 MB	15.3	17.3	17.5	19.0	20.4	21.8	23.2	24.6	26.0	27.4	28.9	30.3	31.6	33.1	34.5	35.6
4 MC	16.4	18.4	18.6	20.1	21.5	22.9	24.3	25.7	27.1	28.5	30.0	31.4	32.7	33.2	35.6	36.7
6 MB	17.3	19.3	19.5	20.0	22.4	23.8	25.2	26.6	28.0	29.4	30.9	32.3	33.6	35.1	36.5	37.6
6 MC	18.7	20.7	20.9	22.4	23.8	25.2	26.7	28.0	29.4	30.8	32.3	33.7	35.0	36.5	37.9	39.0
8 MB	19.0	21.0	21.2	22.7	24.1	25.5	26.9	28.3	29.7	31.3	32.6	34.0	35.3	36.8	38.2	39.3
8 MC	20.2	22.2	22.4	23.9	25.3	26.7	28.1	29.5	30.9	32.3	33.8	35.2	36.5	38.0	39.4	40.5
10 MB	20.6	22.6	22.8	24.3	25.7	27.1	28.5	29.9	31.3	32.7	34.2	35.6	36.9	38.4	39.8	40.9
10 MC	21.9	23.9	24.1	25.6	27.0	28.4	29.8	31.2	32.6	34.0	35.5	36.9	38.2	39.7	41.1	42.2
12 MB	21.8	23.8	24.0	25.5	26.9	28.3	29.7	31.1	32.5	33.9	35.4	36.8	38.1	39.6	41.0	42.1
12 MC	23.6	25.6	25.8	27.3	28.7	30.1	31.5	32.9	34.3	35.7	37.2	38.6	39.9	41.4	42.8	43.9
14 MB	23.0	25.0	25.2	26.7	28.1	29.5	30.9	32.3	33.7	35.1	36.6	38.0	39.3	40.8	42.2	43.3
14 MC	25.3	27.3	27.5	29.0	30.4	31.8	33.2	34.6	36.0	37.4	38.9	40.3	41.6	43.1	44.5	45.6
16 MB	24.2	26.2	26.4	27.9	29.3	30.7	32.1	33.5	34.9	36.3	37.8	39.2	40.5	42.0	43.4	44.5
16 MC	27.1	29.1	29.3	30.8	32.2	33.6	35.0	36.4	37.8	39.2	40.7	42.1	43.4	44.9	46.3	47.4
18 MB	25.4	27.4	27.6	29.1	30.5	31.9	33.3	35.7	36.1	37.5	39.0	40.4	41.7	43.2	44.6	45.7
18 MC	28.8	30.8	31.0	32.5	33.9	35.3	36.7	38.1	39.5	40.9	42.4	43.8	45.1	46.6	48.0	49.1
20 MB	26.6	28.6	28.8	30.3	31.7	33.1	34.5	35.9	37.3	38.7	40.2	41.6	42.9	44.4	45.8	46.9
20 MC	30.5	32.5	32.7	34.2	35.6	37.0	38.4	39.8	41.2	42.6	44.1	45.5	46.8	48.3	49.7	50.8
22 MB	27.8	29.8	30.0	31.5	32.9	34.3	35.7	37.1	38.5	39.9	41.4	42.8	44.1	45.6	47.0	48.1
22 MC	32.2	34.2	34.4	35.9	37.3	38.7	40.0	41.5	42.9	44.3	45.8	47.2	48.5	50.0	51.4	52.5
24 MB	29.0	31.0	31.2	32.7	34.1	35.5	36.9	38.3	39.7	41.1	42.6	44.0	45.3	46.8	48.2	49.3
24 MC	33.9	35.9	36.1	37.6	39.0	40.4	41.8	43.2	44.6	46.0	47.5	48.9	50.2	51.7	53.1	54.2
26 MB	30.2	32.2	32.4	33.9	35.3	36.7	38.1	39.5	40.9	42.3	43.8	45.2	46.5	48.0	49.4	50.5
26 MC	35.7	37.7	37.9	39.4	40.8	42.2	43.6	45.0	46.4	47.8	49.3	50.7	52.0	53.5	54.9	56.0
28 MB	31.5	33.5	33.7	35.2	36.6	38.0	39.4	40.8	42.2	43.6	45.1	46.5	47.8	49.3	50.7	51.8
28 MC	37.4	39.4	39.6	41.1	42.5	43.9	45.3	46.7	48.1	49.5	51.0	52.4	53.7	55.2	56.6	57.7
30 MB	32.7	34.7	34.9	36.4	37.8	39.2	40.6	42.0	43.4	44.8	46.3	47.7	49.0	50.5	51.9	53.0
30 MC	39.1	41.1	41.3	42.8	44.2	45.6	47.0	48.4	49.8	51.2	52.7	54.1	55.4	56.9	58.3	59.4

APPLICATION VII

PIECE HANDLING
MULTI-VARIABLE CHART

REACH + GRASP + MOVE + RELEASE

REACH	GRASP	MOVE	RELEASE
R_B	G1A	M_B	RL1
R_C	G1B	M_C	RL2
	G1C		
3-30"	G4	3-30"	
	G5	WEIGHT	

MAX. VARIANCE FROM ACTUAL = + OR - 3%

TRACTOMOTIVE CORP. — I. E. DEPT.

CL									
RB	3	4	5	6	7	8&9	10	11	12
RC			3	4	5	6&7	8	9	10
RB			3	4	5	6	7	8	9&10
RC					3	4	5	6	7&8
RB				3	4		5	6	7
RC						3		4	5
RB					3	4	5	6	7
RC							3	4	5
RB						3		4	5
RC									3
RB								3	
RC									
RB									
RC									
RB									
RC									
RB									
RC									
RB									
RC									
RB									
RC									
RB									
RC									

WEIGHT IN POUNDS UP TO

DISTANCE MOVED IN INCHES

47.5 MC	47.5 MB	42.5 MC	42.5 MB	37.5 MC	37.5 MB	32.5 MC	32.5 MB	27.5 MC	27.5 MB	22.5 MC	22.5 MB	17.5 MC	17.5 MB	12.5 MC	12.5 MB	7.5 MC	7.5 MB	2.5 MC	2.5 MB									
																			3	11.0	12.1	13.3	14.3	15.3	16.2	17.3	18.0	18.9
																		3	4	12.1	13.2	14.4	15.4	16.4	17.2	18.4	19.1	20.0
																	3	4	5	13.4	14.5	15.7	16.7	17.7	18.5	19.7	20.4	21.3
																3	4	5	6	14.5	15.6	16.8	17.8	18.8	19.7	20.8	21.5	22.4
															3			6	7	15.3	16.4	17.6	18.6	19.6	20.5	21.6	22.3	23.2
														3		4	5	7	8	16.3	17.4	18.6	19.6	20.6	21.5	22.6	23.3	24.2
															4	5	6	8	9&10	17.2	18.3	19.5	20.5	21.5	22.4	23.5	24.2	25.1
													3	4	5		7	9		17.9	19.0	20.2	21.2	22.2	23.1	24.2	24.9	25.8
												3	4			6	8	10	12	18.7	19.8	21.0	22.0	23.0	23.9	25.0	25.7	26.6
											3			5	6	7	9	11		19.5	20.6	21.8	22.8	23.8	24.7	25.8	26.5	27.4
												4	5	6	7	8	10	12	14	20.3	21.4	22.6	23.6	24.6	25.5	26.6	27.3	28.2
									3	3	4		6	7	8	9	11	13	16	21.2	22.3	23.5	24.6	25.6	26.5	27.6	28.3	29.2
												5	7	8	9	10	12	14	18	22.1	23.2	24.4	25.4	26.4	27.3	28.4	29.1	30.0
								3	4	4	5	6	8	9	10	11	14	15	19	23.0	24.1	25.3	26.3	27.3	28.2	29.3	30.0	30.9
							3			5	6	7		10	12	12	16	16	20	23.9	25.0	26.2	27.3	28.3	29.2	30.3	31.0	31.9
						3	4	4	5	6	7	8	9&10	11	13	13	17	17	22	24.9	26.0	27.2	28.3	29.3	30.2	31.3	32.0	32.9
					3			5	6	7	8	9	11	12	14	14	18	18	24	26.0	27.1	28.3	29.3	30.3	31.2	32.3	33.0	33.9
				3	4	4	5		7	8	9	10	12	13	16	16	20	20	26	27.1	28.2	29.4	30.4	31.4	32.3	33.4	34.1	35.0
			3			5	6	6&7	8	9	10	11	14	14	18	17	22	21	28	28.1	29.2	30.4	31.4	32.4	33.3	34.4	35.1	36.0
		3	4	4	5		7	8	9	10	12	12	16	15	20	18	24	22	30	29.3	30.4	31.6	32.6	33.6	34.5	35.6	36.3	37.
	3			5	6	6&7	8	9	10	11	14	14	18	16	22	20	26	24		30.5	31.6	32.8	33.8	34.8	35.7	36.8	37.5	38.
3	4	4	5	6	8	8	9&10	10	12	12	16	14	20	18	24	21	28	25		31.8	32.9	34.1	35.1	36.1	37.0	38.1	38.8	39.
4	5	5	6&7	7	8	9	11	11	14	14	18	16	22	20	26	22	30	26		33.1	34.2	35.4	36.4	37.4	38.3	39.4	40.1	41.
5	6	6	8	8	9&10	10	12	12	16	15	20	18	24	21	28	24		28		34.5	36.6	36.8	37.8	38.8	39.7	40.8	41.5	42.
	7	7&8	9	9&10	12	12	14	14	18	16	22	19	26	22	30	26		30		36.0	37.1	38.3	39.3	40.3	41.2	42.3	43.0	43.
6&7	8	9	10	11	14	13	16	15	20	18	24	20	28	24		27				37.4	38.5	39.7	40.7	41.7	42.6	43.7	44.4	45.
8	9	10	12	12	15	14	18	16	22	20	26	22	30	26		28				39.0	40.1	41.3	42.3	43.3	44.2	45.3	46.0	46.
9	10&12	11	14	14	16&18	16	20	18	24	21	28	24		28		30				40.7	41.8	43.0	44.0	45.0	45.9	47.0	47.7	48.
10	13	12	16	15	20	17	22	20	26	22	30	26		29						42.4	43.5	44.7	45.7	46.7	47.6	48.7	49.4	50.
12	14	14	18	16	22	18	24	22	28	24		28		30						44.1	45.2	46.4	47.4	48.4	49.3	50.4	51.1	52.
14	16&18	16	20	18	24	20	26&28	23	30	26		30								46.0	47.1	48.3	49.3	50.3	51.2	52.3	53.0	53.
15	20	17	22	20	26	22	30	24		28										47.9	49.0	50.2	51.2	52.2	53.1	54.2	54.9	55.
16	22	18	24	21	28	24		26		30										49.8	50.9	52.1	53.1	54.1	55.0	56.1	56.8	57.
18	24	20	26	22	30	26		28												51.8	52.9	54.1	55.1	56.1	57.0	58.1	58.8	59.
20	26	22	28&30	24		28		30												54.0	55.1	56.3	57.3	58.3	59.2	60.3	61.0	61.
22	28	24		26		30														56.2	57.3	58.5	59.5	60.5	61.4	62.5	63.2	64.
23	30	26		28																58.5	59.6	60.8	61.8	62.8	63.7	64.8	65.5	66.
24		28		30																60.9	62.0	63.2	64.2	65.2	66.1	67.2	67.9	68.
26		30																		63.4	64.5	65.7	66.7	67.7	68.6	69.7	70.4	71.
28&30																				66.0	67.1	68.3	69.3	70.3	71.2	72.3	73.0	73.

Exhibit D

DISTANCE REACHED IN INCHES																								TYPE OF GRASP W/RL2	W/RL1
12	13	14	16	17	18	20	21	22	24	26	28	29	30										RB	G5	
10	12	13	14	15	16	18	20	21	22	24	26	28	30										RC		
9&10	11	12	13	14	16	17	18	20	22	23	24	26	28	30									RB	G1A	G5
7&8	9	10	11	12	14	15	16	18	20	22	23	24	26	28	30								RC		
7	8&9	10	11	12	14	15	16	18	20	21	22	24	26	28	30								RB	G1B	
5	6&7	8	9	10	12	13	14	16	18	19	20	22	24	26	28	30							RC		
7	8	9	10	12	13	14	16	17	18	20	22	24	26	28	30								RB		G1A
5	6	7	8	9&10	11	12	14	16	17	18	20	22	24	26	28	30							RC		
5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	27	28&30							RB		G1B
3	4	5	6	7	8&9	10	12	13	14	16	18	20	22	24	26	28	30						RC		
	4	5	6	7	8	9&10	11	12	14	16	17	18	20	22	24	26	28	30					RB	G1C1	
		3	4	5	6	7&8	9	10	12	14	16	18	19	20	22&24	26	28	30					RC	G4A	
	3	4		5	6	7&8	9	10	12	14	15	16	18	20	22	24	26	28&30					RB	G1C2	
			3		4	5&6	7	8&9	10	12	14	16	17	18	20	22&24	26	28	30				RC		
		3	4	5	6	7	8&9	10	12	13	14	16	18	20	22	24	26	28	30				RB	G4B	G1C1
				3	4	5	6&7	8	9&10	11	12	14	16	18	20	22	24	26&28	30				RC		G4A
				3	4	5	6	7&8	9	10	12	14	16	18	20	22	24	26	28	30			RB	G1C3	G1C2
						3	4	5&6	7	8&9	10	12	14	16	18	20	22	24	26	28&30			RC		
				3	4	5	6	7	8&9	10	12	14	16	18	20	22	24	26	28	30			RB		G4B
						3	4	5	6&7	8	9&10	12	14	16	18	20	22	24	26	28	30		RC		
						3	4	5	6	7&8	9&10	11	12	14	16	18	20	22&24	26	28	30		RB	G4C	G1C3
								3	4	5&6	7&8	9	10	12	14	16&18	20	22	24	26	28&30		RC		
								3	4	5	6&7	8&9	10	12	14	16	18	20	22	24	26&28	30	RB		G4C
										3	4&5	6&7	8	9&10	12	14	16	18	20	22&24	26	28&30	RC		
18.9	19.7	20.5	21.4	22.3	23.2	24.2	25.2	26.3	27.3	28.4	29.6	30.8	32.2	33.5	34.9	36.4	37.8	39.4	41.0	42.6	44.5	46.4			
20.0	20.8	21.6	22.5	23.4	24.3	25.3	26.3	27.4	28.4	29.5	30.7	31.9	33.3	34.6	36.0	37.5	38.9	40.5	42.1	43.7	45.6	47.5			
21.3	22.1	22.9	23.8	24.7	25.6	26.6	27.6	28.7	29.7	30.8	32.0	33.2	34.6	35.9	37.3	38.8	40.2	41.8	43.4	45.0	46.9	48.8			
22.4	23.2	24.0	24.9	25.8	26.7	27.7	28.7	29.8	30.8	31.9	33.1	34.3	35.7	37.0	38.4	39.9	41.3	42.9	44.5	46.1	48.0	49.9			
23.2	24.0	24.8	25.7	26.6	27.5	28.5	29.5	30.6	31.6	32.7	33.9	35.1	36.5	37.8	39.2	40.7	42.1	43.7	45.3	46.9	48.8	50.7			
24.2	25.0	25.8	26.7	27.6	28.5	29.5	30.5	31.6	32.6	33.7	34.9	36.1	37.5	38.8	40.2	41.7	43.1	44.7	46.3	47.9	49.8	51.7			
25.1	25.9	26.7	27.6	28.5	29.4	30.4	31.4	32.5	33.5	34.6	35.8	37.0	38.4	39.79	41.1	42.6	44.0	45.6	47.2	48.8	50.7	52.6			
25.8	26.6	27.4	28.3	29.2	30.1	31.1	32.1	33.2	34.2	35.3	36.5	37.7	39.1	40.4	41.8	43.3	44.7	46.3	47.9	49.5	51.4	53.3			
26.6	27.4	28.2	29.1	30.0	30.9	31.9	32.9	34.0	35.0	36.1	37.3	38.5	39.9	41.2	42.6	44.1	45.5	47.1	48.7	50.3	52.2	54.1			
27.4	28.2	29.0	29.9	30.8	31.7	32.7	33.7	34.8	35.8	36.9	38.1	39.3	40.7	42.0	43.4	44.9	46.3	47.9	49.5	51.1	53.0	54.9			
28.2	29.0	29.8	30.7	31.6	32.5	33.5	34.5	35.6	36.6	37.7	38.9	40.1	41.5	42.8	44.2	45.7	47.1	48.7	50.3	51.9	53.8	55.7			
29.2	29.9	30.7	31.6	32.5	33.4	34.4	35.4	36.5	37.5	38.6	39.8	41.0	42.4	43.7	45.1	46.6	48.0	49.6	51.2	52.8	54.7	56.6			
30.0	30.8	31.6	32.5	33.4	34.3	35.3	36.3	37.4	38.4	39.5	40.7	41.9	43.3	44.6	46.0	47.5	48.9	50.5	52.1	53.7	55.6	57.5			
30.9	31.7	32.5	33.4	34.3	35.2	36.2	37.2	38.3	39.3	40.4	41.6	42.8	44.2	45.5	46.9	48.4	49.8	51.4	53.0	54.6	56.5	58.4			
31.9	32.6	33.4	34.3	35.2	36.1	37.1	38.1	39.2	40.2	41.3	42.5	43.7	45.1	46.4	47.8	49.3	50.7	52.3	53.9	55.5	57.4	59.3			
32.9	33.6	34.4	35.3	36.2	37.1	38.1	39.1	40.2	41.2	42.3	43.5	44.7	46.1	47.4	48.8	50.3	51.7	53.3	54.9	56.5	58.4	60.3			
33.9	34.7	35.5	36.4	37.3	38.2	39.2	40.2	41.3	42.3	43.4	44.6	45.8	47.2	48.5	49.9	51.4	52.8	54.4	56.0	57.6	59.5	61.4			
35.0	35.6	36.6	37.5	38.4	39.3	40.3	41.3	42.4	43.4	44.5	45.7	46.9	48.3	49.6	51.0	52.5	53.9	55.5	57.1	58.7	60.6	62.5			
36.0	36.8	37.6	38.5	39.4	40.3	41.3	42.3	43.4	44.4	45.5	46.7	47.9	49.3	50.6	52.0	53.5	54.9	56.5	58.1	59.7	61.6	63.5			
37.2	38.0	38.8	39.7	40.6	41.5	42.5	43.5	44.6	45.6	46.7	47.9	49.1	50.5	51.8	53.2	54.7	56.1	57.7	59.3	60.9	62.8	64.7			
38.4	39.2	40.0	40.9	41.8	42.7	43.7	44.7	45.8	46.8	47.9	49.1	50.3	51.7	53.0	54.4	55.9	57.3	58.9	60.5	62.1	64.0	65.9			
39.7	40.5	41.3	42.2	43.1	44.0	45.0	46.0	47.1	48.1	49.2	50.4	51.6	53.0	54.3	55.7	57.2	58.6	60.2	61.8	63.4	65.3	67.2			
41.0	41.8	42.6	43.5	44.4	45.3	46.3	47.3	48.4	49.4	50.5	51.7	52.9	54.3	55.6	57.0	58.5	59.9	61.5	63.1	64.7	66.6	58.5			
42.4	43.2	44.0	44.9	45.8	46.7	47.7	48.7	49.8	50.8	51.9	53.1	54.3	55.7	57.0	58.4	59.9	61.3	62.9	64.5	66.1	68.0	69.9			
43.9	44.7	45.5	46.4	47.3	48.2	49.2	50.2	51.3	52.3	53.4	54.6	55.8	57.2	58.5	59.9	61.4	62.8	64.4	66.0	67.6	69.5	71.4			
45.3	46.1	46.9	47.8	48.7	49.6	50.6	51.6	52.7	53.7	54.8	56.0	57.2	58.6	59.9	61.3	62.8	64.2	65.8	67.4	69.0	70.9	72.8			
46.9	47.7	48.5	49.4	50.3	51.2	52.2	53.2	54.3	55.3	56.4	57.6	58.8	60.2	61.5	62.9	64.4	65.8	67.4	69.0	70.6	72.5	74.4			
48.6	49.4	50.2	51.1	52.0	52.9	53.9	54.9	56.0	57.0	58.1	59.3	60.5	61.9	63.2	64.6	66.1	67.5	69.1	70.7	72.3	74.2	76.1			
50.3	51.1	51.9	52.8	53.7	54.6	55.6	56.6	57.7	58.7	59.8	61.0	62.2	63.6	64.9	66.3	67.8	69.2	70.8	72.4	74.0	75.9	77.8			
52.0	52.8	53.6	54.5	55.4	56.4	57.3	58.3	59.4	60.4	61.5	62.7	63.9	65.3	66.6	68.0	69.5	70.9	72.5	74.1	75.7	77.6	79.5			
53.9	54.7	55.5	56.4	57.3	58.2	59.2	60.2	61.3	62.3	63.4	64.6	65.8	67.2	68.5	69.9	71.4	72.8	74.4	76.0	77.6	79.5	81.4			
55.8	56.6	57.4	58.3	59.2	60.1	61.1	62.1	63.2	64.2	65.3	66.5	67.7	69.1	70.4	71.8	73.3	74.7	76.3	77.9	79.5	81.4	83.3			
57.7	58.5	59.3	60.2	61.1	62.0	63.0	64.0	65.1	66.1	67.2	68.4	69.6	71.0	72.3	73.7	75.2	76.6	78.2	79.8	81.4	83.3	85.2			
59.7	60.5	61.3	62.2	63.1	64.0	65.0	66.0	67.1	68.1	69.2	70.4	71.6	73.0	74.3	75.7	77.2	78.6	80.2	81.8	83.4	85.3	87.2			
61.9	62.7	63.5	64.4	65.3	66.2	67.2	68.2	69.3	70.3	71.4	72.6	73.8	75.2	76.5	77.9	79.4	80.8	82.4	84.0	85.6	87.5	89.4			
64.1	64.9	65.7	66.6	67.5	68.4	69.4	70.4	71.5	72.5	73.6	74.8	76.0	77.4	78.7	80.1	81.6	83.0	84.6	86.2	87.8	89.7	91.6			
66.4	67.2	68.0	68.9	69.8	70.7	71.7	72.7	73.8	74.8	75.9	77.1	78.3	79.7	81.0	82.4	83.9	85.3	86.9	88.5	90.1	92.0	93.9			
68.8	69.6	70.4	71.3	72.2	73.1	74.1	75.1	76.2	77.2	78.3	79.5	80.7	82.1	83.4	84.8	86.3	87.7	89.3	90.9	92.5	94.4	96.3			
71.3	72.1	72.9	73.8	74.7	75.6	76.6	77.6	78.7	79.7	80.8	82.0	83.2	84.6	85.9	87.3	88.8	90.2	91.8	93.4	95.0	97.0	98.8			
73.9	74.7	75.5	76.4	77.3	78.2	79.2	80.2	81.3	82.3	83.4	84.6	85.8	87.2	88.5	89.9	91.4	92.8	94.4	96.0	97.6	99.5	101.4			

JULY 1, 1958

DMM:KOC

APPLICATION VII

Exhibit E

STANDARD MOTION PATTERN ANALYSES

ELEMENT Hand Turn - Round or nearly round objects.

LIMITATIONS 1) Spin turning - no resistance
2) Normal turn - slight resistance, less than 2.5#
3) Heavy turn - considerable resistance, up to 12.5#
4) Max size of object - 2-1/2 in. dia.

ANALYSES

SPIN TURNING Rotation: 360° per move

First Move	1.6	RfBm	W/fingers to object
	-	G5	Object
	1.2	mM2Bm	To rotate objects
	-	RL2	Rotation object
	2.2	mR1E	Of fingers away from object
	5.0		
Ea. Add'l Move	5.3	R3A	W/Fingers back to grasp
	1.6	RfBm	W/Fingers to object
	-	G5	Rotating object
	1.2	mM2Bm	To rotating object
	-	RL2	Rotating object
	2.2	mR1E	Of fingers away from object
	10.3		

TURNING WITH RESISTANCE Rotation: Up to 1/2" - 1 move = 360°
1/2 to 1" - 1 move = 180°
1 to 2-1/2 - 1 move = 120°

	Normal		Heavy		
First Move	2.0	GIA	2.0	GIA	Object
	4.6	M2B	9.0	M2B12.5	To rotate object
	2.0	RL1	2.0	RL1	Object
	8.6		13.0		
Ea. Add'l Move	4.0	R2A	4.0	R2A	W/Fingers back to grasp
	2.0	GIA	2.0	GIA	Object
	4.6	M2B	9.0	M2B12.5	To rotate object
	2.0	RL1	2.0	RL1	Object
	12.6		17.0		

NOTE: Elements preceded by an R_B to the object or by engage nut (03-SMP.01). Elements followed by a reach away or to another object or by hand tighten (03-SMP.10).

Exhibit G

MTM ELEMENT ANALYSIS SUMMARY

File 102-03.06-01

Element Assemble & Tighten Nut to Secure Plates Part No.

(5/8-11 Bolt 2" Long). Opera No.

1. Material 3. Material Handling 5. Safety

2. Tools 4. Quality 6. Misc.

(Sample Summary for a Standard Data Element to Show Development From Standard Motion Patterns (SMP'S) And From Reach - Grasp - Move - Release Multi-variable Charts).

No.	ELEMENT DESCRIPTION	Total Per Cycle
MMC	Obtain Nut from Mach. Table R12B, G1A, M12C	29.8
03-SMP .01-2	Engage Nut	26.2
03-SMP .02-4	Hand Turn -5 Rev. - Normal Res. 1-1/8" Dia. Nut	185.0
MVC	Obtain Wrench From Bench R20C, G1A, M10C	35.0
03-SMP .03-7	Secure Nut w/Wrench 16" Box - 22.5# Res.	430.8
03-SMP .04-7	Heavy Tighten w/Wrench 16" Box	315.4
MVC	Aside Wrench to Bench M15C,RL1,R3E (B)	25.3
	TOTAL TMU PER CYCLE	1047.5

Exhibit F

October 30, 1958 03-SMP.02

HAND TURN

HAND TURN ROUND OR NEARLY ROUND OBJECTS - IN TMU'S

Resistance	Size of Object Dia.	Ref. Code	1	2	3	4	5	6	7	8	9	10	Ea. Add'l.
			No. of Complete Revolutions										
Spin Turn	1 to 2-1/2	02-1	5.0	15.3	25.6	35.9	46.2	56.5	66.8	77.1	87.4	97.7	10.3
Normal	Thru 1/2	02-2	8.6	21.2	33.8	46.4	59.0	71.6	84.2	98.6	109.4	122.0	12.6
	1/2 thru 1	02-3	21.2	46.4	71.6	96.8	122.0	147.2	172.4	197.6	222.8	247.0	25.2
	1 thru 2-1/2	02-4	33.8	71.6	109.4	147.2	185.0	222.8	260.6	298.4	336.2	374.0	37.8
Heavy	Thru 1/2	02-5	13.0	30.0	47.0	64.0	81.0	98.0	115.0	132.0	149.0	166.0	17.0
	1/2 thru 1	02-6	30.0	64.0	98.0	132.0	166.0	280.0	234.0	268.0	302.0	336.0	34.0
	1 thru 2-1/2	02-7	47.0	98.0	149.0	200.0	251.0	302.0	358.0	404.0	455.0	506.0	51.0

DEVELOPMENT

Normal & Heavy	1st Rev.	Ea. Add'l. Rev.
Thru 1/2	C	V
1/2 thru 1	C + V	2V
1 thru 2-1/2	C + V2	3V
Spin Turn 1 thru 2-1/2	C	V

C = First Move (Normal = 8.6; Heavy = 13.0) (Spin Turn = 5.0)
V = Ea. Add'l. Move (Normal = 12.6; Heavy = 17.0) (Spin Turn =10.3)

ANNOUNCEMENT

EVENT	Annual Cornell University Industrial Engineering Seminars
SPONSOR	Department of Industrial and Engineering Administration, Sibly School of Mechanical Engineering, Cornell University
PLACE	Cornell University, Ithaca, New York
TIME	June 16 through June 19, 1959
PROGRAM	A series of seminar discussions covering each of the following eight areas: A) Industrial Management B) Manufacturing Engineering C) Engineering Administration D) Small Plant Management E) Methods and Work Measurement F) Computers in Production Planning G) Applied Industrial and Engineering Statistics H) Statistical Aspects of Component Reliability In addition, all participants attend general sessions.
DISCUSSION LEADERS AND SPEAKERS	Specialists from both industry and the staff of Cornell University
FOR WHOM	Operating management personnel in line supervision and staff positions in industrial engineering, production engineering, engineering administration, research and development, quality control, cost accounting and cost production, production control, materials control, purchasing, and data processing.

For additional information contact:

Andrew Schultz, Jr.
Department of Industrial and Engineering Administration
Upson Hall
Cornell University
Ithaca, New York

EFFECTIVE MARCH 1, 1959 **ORDER BLANK**

RESEARCH REPORTS	QUANTITY	UNIT PRICE Member, Academic, Library	UNIT PRICE Non-Member	EXTENSIONS
R.R. 101		$ .75	$10.00	
R.R. 102		.50	10.00	
R.R. 104		.50	10.00	
R.R. 105		2.25	15.00	
R.R. 106		2.25	15.00	
R.R. 107		2.25	15.00	
R.R. 108		2.25	15.00	
R.R. 109		2.50	15.00	
R.R. 110		2.50	15.00	
Application Training Supplement		2.00	2.00	
Conference Proceedings				
1954, 1955, 1956 MTM Conference		3.00	3.00	
1957 MTM Conference		5.00	7.50	
1958 MTM Conference		5.00	7.50	
Data Cards				
Detailed Paper				
Detailed Plastic				
Condensed (Plastic)				
Simplified (Paper)				
Analysis Sheets (Per Pad of 100)				
MTMA-1001		2.00		
MTMA-1002		2.50		
MTMA-1003		2.25		

NAME ______________________________ PLEASE SEND BILL ______

POSITION ______________ COMPANY ______________ PAYMENT ENCLOSED ______

Remittance must accompany orders under $5.00.

ADDRESS ______________________________

Send order to: MTM Association for Standards and Research, 216 So. State St., Ann Arbor, Mich.

- -

Please send . . . . . . copy (copies) of the

Journal of Methods Time Measurement

☐ **Enclosed check in the amount of $. . . . .**

Name . . . .

Address . . . .

Subscription Rate:

Domestic - U.S. and possessions and Canada - $2.50 per year
Other - $3.50 per year

Make checks payable to the MTM Association, 216 S. State Street, Ann Arbor, Michigan.


MTM
Journal of Methods-Time Measurement
In This Issue
MTM Research on Apply Pressure
Recent Research on "Blind" Grasp
MTM Basic Specifications
MTM as Applied to Janitorial Services
VOL. V NO. 4 Nov.-Dec. 1958 MTM ASSOCIATION
PROCEEDINGS
Seventh Annual International MTM Conference September 25, 26, 1958
Sponsored by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH
HOTEL STATLER, NEW YORK CITY
RESEARCH REPORTER
APPLY PRESSURE PROGRESS
WHAT ARE OUR RESEARCH AIMS?
OPERATING TESTING POSITION DATA
METHODS—TIME MEASUREMENT RESEARCH STUDIES
A RESEARCH METHODS MANUAL
MTM ASSOCIATION
Published by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH
METHODS—TIME MEASUREMENT RESEARCH STUDIES
A STUDY OF ARM MOVEMENTS INVOLVING WEIGHT
MTM ASSOCIATION
Published by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH
METHODS—TIME MEASUREMENT RESEARCH STUDIES
A STUDY OF POSITIONING MOVEMENTS
I. THE GENERAL CHARACTERISTICS
II. SPECIAL STUDIES SUPPLEMENT
MTM ASSOCIATION
Published by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH
METHODS—TIME MEASUREMENT RESEARCH STUDIES
A STUDY OF POSITIONING MOVEMENTS
III. APPLICATION TO INDUSTRIAL WORK MEASUREMENT
MTM ASSOCIATION
Published by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH
METHODS—TIME MEASUREMENT RESEARCH STUDIES
AN ANALYSIS OF SHORT REACHES AND MOVES
MTM ASSOCIATION
Published by THE MTM ASSOCIATION FOR STANDARDS AND RESEARCH

RESEARCH REPORTS

R.R. 101 Disengage

This report contains a preliminary study of the element disengage. While it is still classified as tentative, the report contains some extremely interesting conclusions on the nature and theory of this element.

R.R. 102 Reading Operations

The first step in the use of MTM for establishing reading time standards is contained in this report. In addition, the report contains a synopsis of the work done in this field by 11 leading authorities.

R.R. 104 MTM Analysis of Performance Rating Systems

A talk presented at the SAM-ASME Time and Motion Study Conference, April 1952. It contains an analysis of performance rating systems and various performance Rating Films from an MTM standpoint.

R.R. 105 Simultaneous Motions

This report represents almost two man-year's work on a study of Simultaneous Motions. It is a final report of the Simultaneous Motions project undertaken by the MTM Association. While it does not purport to provide complete and exhaustive answers to all problems in the field of Simultaneous Motions, it presents a great deal of new and valuable information which should be of interest to every MTM practitioner.

R.R. 106 Short Reaches and Moves

This report contains an analysis of the characteristics of Reaches and Moves at very short distances. It develops important conclusions concerning the application of MTM to operations involving these short distance elements.

R.R. 107 A Research Methods Manual

The research activity of the Association has developed an effective and comprehensive set of methods for carrying on research in human motions. This report details the major techniques used. Adequate sources of motion data, film analysis, data recording, and statistical methods of analysis are among the topics discussed.

R.R. 108 A Study of Arm Movements Involving Weight

In this report, the results of a large investigation into the effect of weight on the performance times of arm movements are presented. While more effective means of determining correct time allowances for moving weights are given, the comprehensive discussion of the whole area of weight phenomena is probably of more fundamental importance. The effect of such conditions of performance as the use of one or two hands, sliding vs. spatial movements, and male and female performance are among the topics presented.

R.R. 109 A Study of Positioning Movements

I. The General Characteristics. II. Appendix.
This report, the first of two position reports, defines "positioning movements and the interrelation of component movements." The study is limited to the laboratory analysis, and contains an appendix dealing with several subjects outside the major objectives.

R.R. 110 A Study of Positioning Movements

III. Application to Industrial Work Measurement.
This report, the second on position, relates the results of the position research to the field of application. This study deals with actual industrial operators and work measurement tools, and the evolution of an improved and more efficient technique for controlling and improving manual activity through better understanding of positioning movements.

4	22.5	16.7	9.7	10.1
	23.9	18.0	10.5	11.5
	25.3	19.2	11.3	12.9
	26.7	20.4	12.1	14.4
		21.7	12.9	15.8
		22.9	13.7	17.3
			14.5	18.8
			15.3	20.2
				21.7
				23.2

... single object in ... which may vary ... ntly from cycle to cycle.

... loca- ... other ... other hand

C Reach to object jumbled with other objects in a group so that search and select occur.

D Reach to a very small object or where accurate grasp is required.

E Reach to indefinite location to get hand in position for body balance or next motion or out of way.

Cas...		
1A		
1B		
1C1		7.
1C2		8.7
1C3		10.8
2		5.6
3		5.6
4A	7.3	
4B	9.1	
4C	12.9	
5	0	

Regr...
Trans...
Object ju... than 1"
Object jumb... x 1/8" to 1"
Object jumbled than 1/4" x 1/4"
Contact, sliding or ...

TABLE II—MOVE—M

...nd	Wt. Allowance		CASE AND DESCRIPTION
	Wt. (lb.) Up to	Fac-tor	Con-stant TMU	
	2.5	0	0	**A** Move object to other hand or against stop.
	1.06	2.2		
	...11	3.9		**B** Move object to approximate or in-definite location.
		5.6		
	...4			...ve object to ex-...cation.

TABLE V—...

CLASS OF FIT		Sy...
1—Loose	No pressure required	SS
		NS
		S
2—Close	Light pressure required	SS
		NS
		S
3—Exact	Heavy pressure required.	SS
		NS

*Distance moved to engage—1" or less.

... AP

180°

4

TABLE VI—RELEASE—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release.

TABLE VII—DISE...

CLASS OF FI...

1—Loose—... effort ... sub...

2—...

TABLE VIII—EYE...

Eye Trav...

47...

Cas
1A
B
7.
8.7
.8
Regr
Transi
Object ju
than 1"
ct jumbl
" to 1"
jumbled
" x 1/4"
ding or
V—
Sy
SS
NS
S
SS
47.
DISE